



TEAGASC
RESEARCH IMPACT HIGHLIGHTS IN 2019



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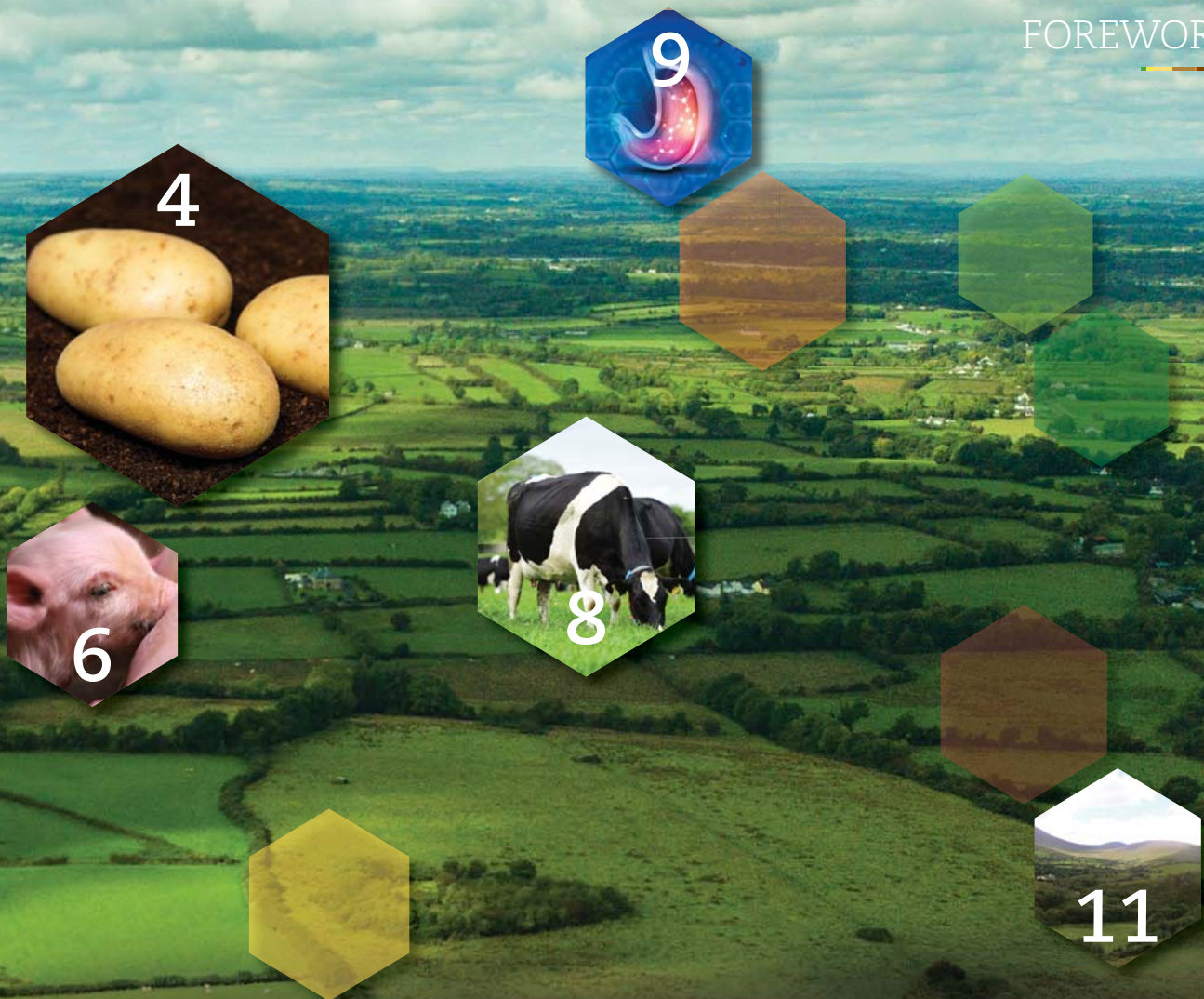
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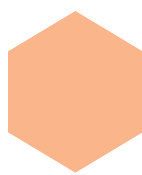
The annual expenditure on research in Teagasc is approximately €75 million, which comes from a variety of sources. These include the core grant-in-aid funding allocated by the Department of Agriculture, Food and the Marine (DAFM), and competitive funding awarded nationally – principally, the FIRM, Stimulus and CoFoRD programmes of the DAFM. Other important national sources are Science Foundation Ireland, Enterprise Ireland, the Environmental Protection Agency, and the Irish Research Council, and in recent years our researchers have been very active in winning funding from international programmes such as EU Horizon 2020. Indeed, in comparison with all other research organisations and universities across Europe, Teagasc is ranked fifth in terms of number of projects awarded in the agri-food stream of European funding since Horizon 2020 began in 2014. Farmer levy contributions, industry-funded research, and earnings from services offered and farming activities also provide very important funding.

Given the Teagasc mission to support science-based innovation in the agri-food sector and the wider bioeconomy, it is very important to demonstrate the impact of this investment. In any given year, the impact of Teagasc research is a combination of the continuing impact of past research and the new impact of recent research. This publication highlights some of these new impacts achieved in 2019. The examples selected are from across our programme and include research conducted on issues in soils and the environment, animal production, crop production, food processing, food and health, economics and social science. They are not an exhaustive account of the new impacts of Teagasc’s research but they do demonstrate the breadth of research carried out by Teagasc. The impacts are made in

a range of areas including livestock and crop (including horticulture) production, and the food industry, and also on shaping policy. Achieving impact requires not just the research, but also depends on the work of our advisers and specialists, experts in other organisations and industry, and farmers, food companies and policymakers. Having a range of these actors involved, who ultimately make the changes in what they do based at least in part on our research, greatly helps the achievement of impact. I wish to commend my colleagues in Teagasc who carried out the research reported here or supported it in some way, and other researchers whose work also had impact but is not included in these 20 examples. I would also like to acknowledge the many collaborators we have in universities, institutes of technology and other external bodies, as well as the farming community and agri-food companies, which are directly involved in many of our research projects. We greatly value those contributions. Finally, I would like to thank the funders of the research, which are listed above. I believe it is wise investment and will pay rich dividends across the agri-food industry, the wider economy, and Irish society over the coming years.



Frank O'Mara
Director of Research, Teagasc



Reducing antibiotic use at drying off

George Ramsbottom, Sinead McParland, Clare Clabby, Pablo Silva Bolona

Industry impact: Public concern over the use of antibiotics is rising, especially as it relates to antibiotic usage in agriculture and the implications for antimicrobial resistance. Teagasc research conducted in both research and commercial dairy farms showed that by altering the typical ‘blanket treatment’ of the entire herd with antibiotics at dry-off to treating only potentially infected animals, the amount of antibiotic used in the herd was reduced, with only a small impact on somatic cell count. A high level of hygiene, proper teat-end preparation and using the correct infusion technique at drying off were critical to success. In conjunction with Animal Health Ireland, Teagasc promoted these research results through organised farm walks with over 1,900 farmers in attendance. Since 2017, dry cow antibiotic use has declined by over 10 % to 80 tubes per 100 cows, indicating an increase in the practice of selective dry cow therapy at dry-off.

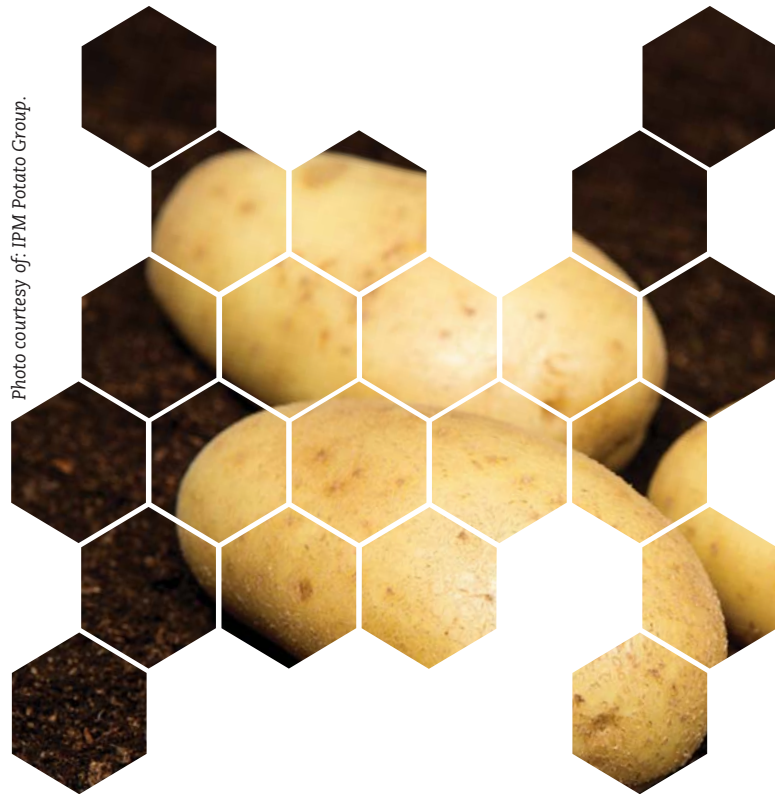
Correspondence: pablo.silvabolona@teagasc.ie

Other contributors and collaborators: John Murphy, Kerry Agribusiness, Animal Health Ireland and Irish Dairy Co-operatives.

Funding: Teagasc grant-in-aid.



Photo courtesy of: IPM Potato Group.



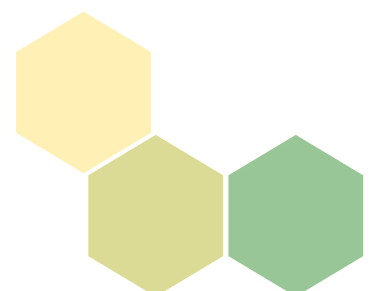
Buster: developing better potato varieties

Dan Milbourne, Denis Griffin

Industry impact: Since 2011, the Teagasc/IPM Potato Group breeding programme has been applying innovative DNA-based marker-assisted selection (MAS) technology to enhance its ability to develop potato varieties that exhibit resistance to multiple diseases and pests, including late blight, potato cyst nematode (PCN), potato virus Y and wart disease. A major target has been to develop varieties resistant to PCN, the most serious pest of potatoes worldwide. Control of this soil-borne pest is problematic; incomplete resistance in varieties and the loss of nematicides can render infested land unsuitable for production. MAS-enhanced breeding at Teagasc has led to the development of Buster, a high-yielding fresh-market variety released in 2019. Buster possesses five resistance genes that give it near complete resistance to both the golden and white forms of PCN, which reduces PCN infestations, mitigating the need for chemical control on infested land.

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Funding and collaborators: IPM Potato Group Limited.



Succession and inheritance – farmers’ perspectives

Anne Kinsella, Brian Leonard (Galway County Council, formerly Teagasc/NUIG), Maura Farrell, Marie Mahon, Cathal O’Donoghue (NUIG)

Industry impact: This research investigated the impact of economic drivers and risks on farmer decision making with regard to farm succession/inheritance. A particular focus was the current generational renewal policy measures and farmers’ perceptions when considering financial aspects of farm transfer. Researchers from the University of Gloucestershire, undertaking an EU study, contacted the project research team to further explore and gain insights on the wider area of generational renewal in agriculture. The overall aim of this European-wide evaluation study was to assess how different Common Agricultural Policy (CAP) measures and instruments affect generational renewal in rural areas with reference to the various forms of support available for young farmers. Face-to-face meetings undertaken for this EU study during 2018/2019 were further informed by a well-attended national stakeholder workshop facilitated by Teagasc and held at Mellows Campus. A key outcome from this EU study was the publication of the 2019 report ‘Evaluation of the impact of the CAP on generational renewal, local development and jobs in rural areas’. A further workshop event to highlight the project research findings was jointly organised by Teagasc and the Royal Dublin Society (RDS) and held in May 2019, bringing together key stakeholders and policymakers. A key outcome of this event was open discussion between multiple stakeholders in the area of generational renewal. The resulting report was circulated to relevant stakeholders and used by the Department of Agriculture, Food and the Marine (DAFM) to inform agricultural policy and future strategy. The project received widespread coverage in national and local media, particularly in relation to the simplified graphical presentation of financial outcomes under various scenarios. Concerns over marriage break-up and potential loss of assets cited from interviews undertaken with farmers also featured. Research findings were presented to various farmer discussion groups and meetings. Research published from this project has garnered much interest from the Cabinet of the Irish Commissioner for Agriculture; findings were further discussed and circulated within DG-AGRI (EC).

Reference: EU report available from: <https://op.europa.eu/en/publication-detail/-/publication/4bd0b0a2-0503-11ea-8c1f-01aa75ed71a1>.

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Contribution of non-research stakeholders: Financial management/collaborative farming specialists and engagement at Transferring the Family Farm clinics.

Key stakeholders: European Commission, University of Gloucestershire, Department of Agriculture, Food and the Marine, Macra na Feirme, Irish Farmers’ Association, Broadmore Research, National Rural Network, Society of Chartered Surveyors Ireland.

Funding: Teagasc Walsh Scholarship Programme and the RDS.

Using white clover to reduce N fertiliser input

Deirdre Hennessy, Michael Egan, Stephen McAuliffe, Maryanne Hurley, Ellen Fitzpatrick

Industry impact: White clover is well suited as a sward species in grazed grassland. White clover can fix atmospheric nitrogen (N) and make it available for plants growing in the sward. Additionally, white clover is known to have greater nutritive value for animal production, particularly when grass quality declines during the reproductive phase in the summer. A project comparing the productivity of grass-only swards receiving 250 kg N/ha per year with grass-white clover swards receiving 150 kg N/ha per year in dairy cow milk production systems has shown that herbage production is the same on the two sward types, and milk production per cow is greater in the grass-white clover system (+30 kg milk solids/cow per year). Additionally, the farm gate N balance is improved as 100 kg N fertiliser/ha less is applied on the grass-clover system and the N exported in milk solids is greater. Based on these results, all grassland farmers applying for derogation from the Nitrates Directive from 2020 onwards have to include a minimum rate of 1.5 kg naked clover seed per ha in the seed mix for all reseedings.

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Other contributors and collaborators: University College Dublin, Queen’s University Belfast.

Funding: Teagasc grant-in-aid, Dairy Research Ireland, Teagasc Walsh Scholarship Programme.



Protecting soil structure

Dermot Forristal, Giulia Bondi, Jer Emmet-Booth, Owen Fenton, David Wall

Industry impact: The increasing weight of machinery and a desire for timeliness in field operations, from crop establishment to grazing early grass, puts increasing pressure on our soils. The maintenance of soil quality is essential to allow it to continue to support production and provide ecosystem services such as nutrient retention and water management. Soil structure damage must be prevented but practical tools to assess this damage have not been available for growers and their advisors to assess soils. In recent collaborative research projects, Teagasc (Johnstown Castle and Oak Park) and UCD have evaluated and developed a range of soil structure techniques for assessing soils. Visual assessment techniques, such as visual evaluation of soil structure (VESS), have been further developed for grassland use (GrassVESS), and a new visual assessment tool, DS, has been developed to assess soil structure in tillage soils, focusing particularly on the transition area between the cultivated topsoil and the subsoil. These techniques, which are simply described in a practical guide, *The Soil Structure ABC*, have been proven to act as an early warning tool on tillage soils – allowing structure differences to be detected before yields are impacted. They are changing farmers' attitudes to soil management, as advisors and specialists, by using these techniques, now have the capacity to clearly illustrate the damage being caused to soils. Their use opens up a whole new era of soil management that should protect this critical resource.

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Other contributors and collaborators: Nick Holden, School of Biosystems and Food engineering, UCD.

Funding: The SQUARE project was funded by the Department of Agriculture, Food and the Marine Research Stimulus Fund (Project 13S468).



Maternal feeding strategies to overcome the challenges of rearing large litters

Hazel Rooney, Keelin O'Driscoll, Peadar Lawlor

Industry impact: Genetic selection for hyper-prolificacy in sows has resulted in a significant increase in the number of piglets born alive per litter, but also in decreased piglet vitality, growth and survival. This poses an enormous challenge to pig producers. In response, we investigated several nutritional strategies with the aim of alleviating some of the negative consequences associated with rearing large litters. Supplementing gestating sows with dietary L-carnitine increased litter size at birth, as well as increasing the weight and carcass muscle depth in progeny at slaughter. Similarly, sugar beet pulp inclusion in sow diets during gestation increased the weight and carcass muscle depth in progeny at slaughter. Lastly, increasing the dietary energy density for sows during lactation improved some traits of piglet vitality. An important impact of this project is the financial benefit that can be gained from utilising these feeding practices. For example, the financial benefit at farm level of the increase in sow litter size at birth and the additional weight of pigs sold at slaughter due to supplementing sows with L-carnitine during gestation is € 1.85 and € 0.59/pig, respectively. The data generated has been instrumental in providing farmers with novel feeding strategies to reduce the impact of increased litter sizes, by increasing piglet vitality and growth. This research has received a very positive response to the use of L-carnitine by those in industry, with nutrition companies increasing their inclusion of L-carnitine in sow premixes. Furthermore, they are promoting the usage of L-carnitine to producers who are looking for novel supplements that can improve sow reproductive performance and piglet viability. The impact of this work was also recognised through receipt of the 2018 British Society of Animal Science Industry Application Award.

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Other contributors and collaborators: John O'Doherty (UCD), Giuseppe Bee and Paolo Silacci (Agroscope, Switzerland).

Funding: The OPTIPIG project was funded by the Department of Agriculture, Food and the Marine FIRM/RSF/CoFoRD 2013 Research Call (grant number 13S428).





A green light for green energy

Declan Bolton, Karl Richards, Owen Fenton

Industry impact: Anaerobic digestion (AD) is a process during which biodegradable materials are decomposed to produce biogas. This is subsequently used to generate heat and electricity, or it is upgraded to methane for injection into the gas grid. If AD is adopted in a sizeable way over the next five years, it will help Ireland to reach targets for legally binding greenhouse gas emission reductions. Roadblocks to this roll-out include concerns with respect to the prevalence and survival of pathogenic bacteria, viruses and parasites via land spreading of AD residues. Results from a four-year joint project between Teagasc (Ashtown and Johnstown Castle), National University of Ireland, Galway, and University College Dublin have shown that land application of AD residues presents less of a risk than the application of cattle slurry. A national framework was delivered for control interventions to aid in the safe application of AD residue to land. Thus, our data provides a green light for AD green energy in Ireland.

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Contribution of non-research stakeholders: Department of Agriculture, Food and the Marine (DAFM) personnel provided veterinary and regulatory input, while several AD companies provided commercial materials and AD process expertise.

Other contributors and collaborators: National University of Ireland, Galway (NUIG) and University College Dublin (UCD).

Funding: This project was funded by the Food Institute Research Measure (FIRM), administered by the Department of Agriculture, Food and the Marine (Project 14SF847).

Teagasc National Farm Survey 2017 Sustainability Report

Cathal Buckley, Trevor Donnellan, Emma Dillon, Kevin Hanrahan, Brian Moran, Mary Ryan

Industry impact: This publication reports on the economic, social, environmental and innovation dimensions of sustainability at farm level using the Teagasc National Farm Survey. Economic (profitability of land, market orientation, productivity of labour and viability), social (household vulnerability, isolation risk, age profile, education and work-life balance), environmental (greenhouse gases, ammonia, nitrogen and phosphorus loss risk) and innovation (various practices) results are reported in detail over the 2012 to 2017 period across dairy, cattle, sheep and tillage farms. The report received widespread coverage in the national media, particularly in the area of the environmental footprint of different farming systems. The report is an exemplar for other organisations to follow internationally, and is valuable for policymakers and the agri-food industry in understanding how best to focus continuing efforts to address farm emissions and contribute to national targets for gaseous emissions reductions.

Reference: Buckley, C., *et al.* (2019). 'Teagasc National Farm Survey 2017 Sustainability Report'. Available from: <https://www.teagasc.ie/media/website/publications/2019/2017-sustainability-report-250319.pdf>.

Correspondence: cathal.buckley@teagasc.ie

Funding: Teagasc grant-in-aid.



Improving supply chain resilience on the island of Ireland

Maeve Henchion

Industry impact: Food fraud is of growing concern to the food industry and the public sector. It is different to food safety as it is intentional as opposed to accidental. Furthermore, because events are relatively infrequent, data about them are limited. Thus, a different approach is required to ensure supply chain integrity. Research, involving a systematic literature review, an all-island survey of food companies, and in-depth interviews with experts across five Organisation for Economic Co-operation and Development (OECD) countries has provided the following: a benchmark against which to assess awareness and activities in the future; a typology of vulnerability management initiatives undertaken by the public and private sector; and, a vulnerability management framework. These are now being used by the public sector and industry to inform the design of intervention strategies. This work has also led to an education and research collaboration – involving Musgrave Group (grocery retailers and wholesalers), University College Cork (UCC), Teagasc and Michigan State University – to develop a multi-stakeholder approach to further build human capacity to ultimately ensure the resilience of supply chains originating on, or existing within, the island of Ireland. The results of this research are being used to teach undergraduate and postgraduate modules in Food Business and Innovation at the Cork University Business School (CUBS) in UCC. This work is also continued through the annual Musgrave-sponsored Food Integrity guest lecture held in autumn each year involving international keynote speakers. Furthermore, articles and reports targeted at industry and wider stakeholders continue to be hosted on the *safeFood*, Teagasc and UCC websites.

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Other contributors and collaborators: Seamus O'Reilly and Alan Sloane (UCC).

Funding: *safeFood*.



NextGen herd proves it is possible

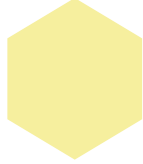
Frank Buckley, Ricki Fitzgerald, Morgan O'Sullivan, Orlaith Quigley

Industry impact: The efficiency of seasonal calving pasture-based milk production systems is dependent on achieving synchrony between feed demand and pasture growth. However, maintaining compact calving year on year is a major challenge. Declining fertility identified in the late 1990s prompted the development and implementation of the Economic Breeding index (EBI), which weights fertility and other functional traits along with production, uniquely reflecting the demands of our seasonal pasture-based calving system. Improving reproduction and longevity remains an overarching goal today. The Next Generation Herd (NextGen) was established at Teagasc Moorepark as a sentinel research herd to validate the performance of futuristic cows selected using the EBI. The performance of the ELITE high EBI cows demonstrates clearly that intensive selection using the EBI will result in performance in line with industry targets: six-week and end of breeding season pregnancy rates have been 73 % and 93 %, respectively, with 59 % of ELITE cows surviving to fifth lactation. The NextGen herd acts as an industry-wide point of reference and highlights the potential to deliver genetic and phenotypic gain by placing the appropriate emphasis on traits of economic importance within a selection objective.

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Other contributors and collaborators: Irish Cattle Breeding Federation, University College Dublin and University College Cork.

Funding: Teagasc grant-in-aid, Dairy Research Ireland.



Residues in milk and dairy powders

Martin Danaher, Mohammad Hossain, Clement Douillet, Mary Moloney

Industry impact: Chlorate and perchlorate residues can contaminate milk due to the use of these chemicals on farms and in dairy processing plants to clean equipment and ensure good hygiene practices. A rapid high-throughput test was developed to accurately measure chlorate and perchlorate residues using liquid chromatography coupled to tandem mass spectrometry. The test method is now used as a service by the dairy industry to monitor the purity of farm milk supply and to troubleshoot dairy processes. This service has been invaluable to the dairy industry, helping it to identify the source of chlorate and perchlorate residues, and has led to a reduction of concentrations to below EU limits. The test, developed by Teagasc, provides the Irish dairy industry with a cost-effective tool to analyse thousands of samples, which gives them a competitive edge over international competitors.

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Contribution of non-research stakeholders: The Irish dairy industry.

Funding: This project was funded through Teagasc grant-in-aid and industry fee-earning services.



Food digestion

André Brodtkorb, Linda Giblin

Industry impact: The link between food and human health is an increasing topic of interest. One strategy to better understand this relationship is to monitor and simulate food disintegration and interactions within the gastrointestinal (GI) tract. Teagasc Moorepark researchers have been at the forefront of developing and standardising lab-based *in vitro* semi-dynamic and static food digestion methods such as the INFOGEST method (Brodtkorb, *et al.*). The latter is now considered the academic and industry standard, and is currently being adopted as an International Dairy Federation/International Organisation for Standardisation (IDF/ISO) standard method. Teagasc continues to perform *in vitro* and *in vivo* human intervention digestion studies for manufacturers of food, food ingredients, supplements and infant formula, in order to assess changes in food structure during GI transit, as well as the bio-accessibility and bio-availability of digested food across the intestinal barrier. The findings from these studies are helping start-ups, small, medium and multinational companies to better position their products on the market and substantiate claims regarding the digestive behaviour of food or food ingredients.

Reference: Brodtkorb, A., *et al.* (2019). 'INFOGEST static *in vitro* simulation of gastrointestinal food digestion'. *Nature Protocols*, 14: 991-1014.

Correspondence: andre.brodtkorb@teagasc.ie

Other contributors and collaborators: University of Leeds, Quadram Institute (both UK), INRAE (France), Riddet Institute (NZ).

Funding: European Cooperation in Science and Technology (COST Action), Dairy Research Ireland, Department of Agriculture, Food and the Marine (FIRM), VistaMilk (SFI), Enterprise Ireland, H2020 Marie Skłodowska-Curie programme.



Breeding for improved meat quality metrics in cattle

Michelle Judge, Donagh Berry, Emily Crofton, Chris Ovenden, Ruffielyn Gravador, Michael Whelan

Industry impact: The permanent and cumulative properties of breeding strategies contribute to their usefulness as a strategy to continuously improve animal performance metrics, including meat quality. As part of a Meat Technology Ireland (MTI) project, a sensory panel was trained using descriptive analysis techniques to detect and describe small differences in meat quality characteristics in fresh beef samples. Genetic and genomic evaluations for meat tenderness, juiciness and flavour were developed and subsequently deployed by the Irish Cattle Breeding Federation, for dairy and beef cattle. This is the first international evaluation for meat quality based on data from trained sensory panels. The trained panel is also being actively used by meat companies to understand various aspects of beef eating quality.

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Other contributors and collaborators: Irish Cattle Breeding Federation, Meat Technology Ireland.

Funding: Meat Technology Ireland.



Maintaining Ireland's Nitrates Derogation – 2019 revision

David Wall, John Spink, Karl Richards

Industry impact: In 2019 Teagasc's Water Quality Working Group made a comprehensive submission in response to the public consultation for the interim review of Ireland's Nitrates Derogation programme. Teagasc reviewed technological and management changes impacting on farm productivity and environmental sustainability. Based on the latest science, specific areas related to soil and nutrient management that have potential to positively impact on water quality, reduce gaseous emissions, enhance biodiversity, and achieve sustainable production on farms were identified. The Teagasc submission was underpinned by the Environmental Research Programme and supported by reviews of the current international scientific literature. The objectives of these proposed amendments were to:

- achieve more effective protection of the rural environment;
- improve efficiency of agricultural production;
- rationalise and simplify the operation of Good Agricultural Practice (GAP) and Nitrates Derogation regulations; and,
- reflect relevant measures in Teagasc's greenhouse gas and ammonia Marginal Abatement Cost Curves (MACC).

In its submission, Teagasc addressed each of the five challenges put forward by the Departments of Agriculture and Environment for environmental sustainability on farms in receipt of derogation to farm more intensively. In total, 17 proposals for amendments to the Nitrates Derogation programme were put forward with a view to achieving more efficient use of nutrients on farms. Given the

challenges of increasing farm productivity while also improving water quality (and reducing greenhouse gas and ammonia emissions), significant changes to the Nitrates

Derogation regulations for the protection of water quality, as well as the achievement of sustainable intensification objectives, have been made in 2020. All of Teagasc's proposals were adopted during the review process and the new regulations were approved by the EU Commission.

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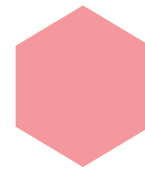
Contribution of non-research

stakeholders: The Water Quality Working Group is a collective effort from Teagasc Research, Knowledge Transfer and Advisory personnel.

Other contributors and collaborators:

Agricultural Sustainability Support Advisory Programme (ASSAP).

Funding: Teagasc grant-in-aid.



AgileTECH for supporting use of technology on farms

Áine Macken-Walsh, Brendan Horan

Industry impact: Use of technologies at farm level is necessary for achieving impact, innovation and sustainability. AgileTECH is a step-by-step model for use in a farmer discussion group setting to support use of grassland management technologies. The model is informed by social science research on farmer decision making and was co-designed by farmers, advisors and scientists. Incorporating tools to leverage the expertise of the advisor and maximise peer-to-peer interaction, AgileTECH begins with goal setting and ends with a customised plan for participating farmers. AgileTECH is now in use by Teagasc advisors and the private sector, and the goal-setting tool has been used by all farmers attending Teagasc Grass10 courses. Teagasc's Knowledge Transfer Directorate has subsequently taken the initiative to adapt the methodology to address antimicrobial and anthelmintic resistance in the context of farmer discussion groups.

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Other contributors and collaborators: Centre for Participatory Strategies, National University of Ireland Galway.

Funding: Department of Agriculture, Food and the Marine Research Stimulus Fund (11-S-148).

Hedgerow mapping

Stuart Green

Industry impact: Teagasc's Agri-Food Business and Spatial Analysis Department has been at the forefront of research into the extent and value of hedgerows as a carbon store. It produced the first hedgerow map for Ireland, estimating the area of hedgerow and scrub in Ireland (up to 4% of the area of the country). In partnership with others in the Environmental Protection Agency (EPA)-funded Hedgerow Carbon Project, 3D methods for estimating carbon sequestered in hedges were developed (0.66 to 3.3 tCO₂/ha per year) for above-ground biomass. In 2019, the Department-led and EPA-funded BRIAR project published its final report – doubling the previous estimated length of “boundary biomass” in Ireland to 680,000 km, including all biomass on boundaries (tree lines, relic hedgerows, etc.), not just a narrow ecological definition of “hedgerow”. Having a fuller understanding of the boundary biomass network allows for more complete modelling of high-nature-value farming resources in Ireland, and increases the apparent value of pockets of biodiversity that are linked through the network of boundary biomass. These projects have proven the carbon resource on farm boundaries and have led to new projects in Teagasc developing hedgerow carbon models and the inclusion of hedgerows in the new National Landcover Map to be published in 2021. As a result of these studies we can now estimate the size of the hedgerow/scrub sink and the reports have designed survey methods to remotely characterise hedgerows, thus identifying the opportunity for hedgerow repair, management and boundary tree planting as a source of new on-farm sequestration, as identified in the 2019 Climate Action Plan.

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Other contributors and collaborators: These hedgerow studies were a series of collaborative projects with the EPA, University College Cork, Treemetrics and FERS Ltd.

Funding: Teagasc grant-in-aid and EPA Strive Funding.





Finishing male hill lambs at light carcass weights

Michael G. Diskin, Francis Campion, Noel Claffey

Industry impact: Ireland produces about 250,000 Scottish Blackface male lambs annually, typically weighing 20-26 kg when weaned. Historically, many of these lambs were slaughtered at light carcass weights for the Italian market, which no longer exists. Such lambs require a prolonged period of feeding to reach live weights of 42-48 kg and carcasses of 18-22 kg. Recent studies at Athenry have shown that it is possible to finish these lambs at live weights of 32-35 kg, producing 12-15 kg carcasses, with an acceptable covering of fat (Fat Class 2), following a short four- to six-week period of intensive feeding. A local producer group, Atlantic Hill Lamb, has now been established in the west and has marketed almost 60,000 of these lambs over the past two years, at a premium of 30 c/kg over French lamb prices. Initially, all lambs were marketed through one processor, though currently three processors have developed markets for these lambs. The research undertaken by Teagasc in Athenry has provided the stimulus for the establishment of the producer group and this blueprint for finishing these lambs has emerged from this research. This option is now being widely adopted by primary hill lamb producers from Kerry to Donegal, who are marketing their lambs directly to the factory. It is estimated that such lambs return an extra margin of € 15 to € 20/lamb. The development of this outlet for hill lambs has also established an improved price for the remaining hill store lambs.

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Contribution of non-research stakeholders: Input from hill sheep farmers led by Brendan Joyce, sheep farmer, Co. Galway.

Funding: Teagasc grant-in-aid.

Developing the cut foliage sector

Helen Grogan, Andy Whelton

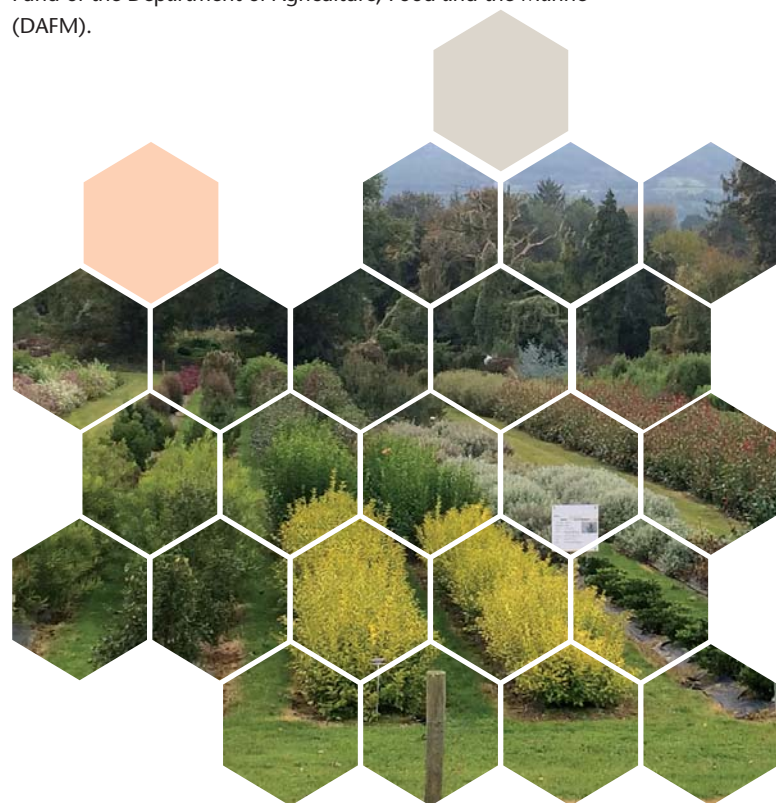
Industry impact: Since 2011, Teagasc has been conducting trials at Kildalton College, Kilkenny, to identify high-quality foliage species for growers to sell into the lucrative € 2.5 billion European cut flower market. Of 150 species tested, 30 grow well in Ireland's unique growing climate. Ten of these are now widely planted in the south and east of the country, especially *Eucalyptus* and *Prunus* (cherry laurel), where current area planted is 200 ha and commercial output has doubled in the past five years. Other species demanded by the market are being scaled up, including more novel types like *Viburnum tinus* 'Purpureum' and grey-leaved cultivars of *Ozothamnus* and *Brachyglottis*. However, challenges in propagation have impacted expansion due to shortages of plant material. Therefore, in collaboration with the industry, research is underway developing traditional and micro-propagation technologies for key species to increase the commercial availability of high-value 'mother' plants for commercial propagation.

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Contribution of non-research stakeholders: Marketing and processing company Forest Produce Ltd, in conjunction with foliage growers in Ireland.

Other contributors and collaborators: Trials are led by Teagasc specialist advisor Andy Whelton. Currently supported by a research project entitled 'New Leaves', a collaborative project with Angela Feechan and Jan-Robert Baars at UCD and industry partner Forest Produce Ltd.

Funding: Cut foliage species trials are Teagasc grant-in-aid funded, while the New Leaves project is funded by the Research Stimulus Fund of the Department of Agriculture, Food and the Marine (DAFM).





Terroir in Irish whiskey production

Maria Kyrleou, Kieran Kilcawley

Industry impact: Irish whiskey (uisce beatha Éireannach) is one of the oldest spirit drinks globally and has European Union Protected Geographical Indication status. Enterprise Ireland, through the Innovation Partnership Programme, has funded a project with Waterford Distillery and Teagasc to investigate the potential of 'terroir' in Irish whiskey distillates. Terroir is the set of all environmental factors that affect a crop's phenotype, including soil, microclimate, and farming practices. Although each step of the distilling process plays a vital role in establishing the flavour complexity of whiskey, the cereal crop allegedly imparts a distinctive sensory profile attributable to its geographical origin and, therefore, may impart a terroir aspect to whiskey. This study evaluated the volatile profiles of new make (before ageing in the barrel) spirits from two different barley varieties cultivated in two distinct sites in Ireland. The results to date highlight a potential impact of geographical location of the barley – greater than that of barley variety – on the aromatic profile of new make spirit. As Waterford Distillery processes the crop from each barley supplier (farmer) separately, it is in a unique position to exploit any potential terroir effect, thus providing a distinct marketing element to the whiskey. Results to date have already transitioned to industry and are currently being used by Waterford Distillery.

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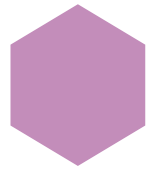
Other contributors and collaborators: Waterford Distillery. Whiskey Terroir was a collaborative project: the barley was managed by Boortmalt Ireland and the distillations were carried out by Tatlock & Thomson (Scotland). Dustin Herb (Oregon State University, USA) provided advice, assistance and statistical analysis.

Funding: The Whiskey Terroir project was funded by Enterprise Ireland (Contract No: IP 2018 0733).



Results-based payments

John Finn



Industry impact: Results-based payments provide farmers with performance-related payments for delivering agreed environmental objectives. For example, higher payments are made for protection of indicator species, and for improved habitat quality, soil health and water quality. Teagasc has been involved in multiple projects that have trialled the implementation of results-based payments: BurrenLIFE, which led to the Burren Programme; KerryLIFE; AranLIFE; and, the RBAPS project (Developing Results Based Agri-environmental Payment Schemes in Ireland and Spain). Across Europe, policymakers and practitioners are looking to Ireland as a leader in this area, and at these projects and programmes as examples of how results-based approaches can be developed and implemented. Lessons from these projects have informed the design of ambitious results-based European Innovation Partnerships (EIPs) that include the Hen Harrier Project, the Pearl Mussel Project, the BRIDE project, and others. These lessons centred on:

- the necessity for combining the specialist skills of farmers, ecologists, advisors and project managers;
- the need to identify relevant specific objectives and indicators that help to best target efforts;
- the important role of advisory support with biodiversity expertise to engage with participant farmers;
- good practice in the development of scoring schemes;
- innovative approaches to link scores to payments;
- different hybrid approaches that combine action-based payments, results-based payments and non-productive investments; and,
- an ability to rapidly measure progress towards the biodiversity targets, and either confirm progress or learn how to improve.

A new book published by Teagasc and the National Parks and Wildlife Service (NPWS) (www.teagasc.ie/farmingfornature) highlights several Irish case studies of results-based payments for biodiversity conservation. It provides details on farm plans, scoring sheets, governance mechanisms, the role of advisory services, the choice of indicators, monitoring details, and explores the relationship between results and payment.

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Other contributors and collaborators: The Burren Programme, AranLIFE, KerryLIFE, the NPWS, the Department of Culture, Heritage and the Gaeltacht, the RBAPS project, Galway-Mayo Institute of Technology, and University College Cork.

Funding: The book was funded through contributions from Teagasc, the NPWS, KerryLIFE, Galway-Mayo Institute of Technology, and University College Cork.



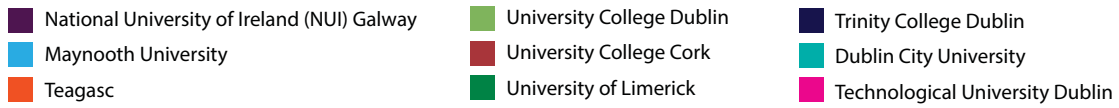


FIGURE 1:
Number of papers by Teagasc and Irish universities that are indexed in Scopus category Agricultural and Biological Sciences (2015-2019).



FIGURE 2:
Number of papers by Teagasc and Irish universities that are indexed in Scopus category Agronomy and Crop Science (2015-2019).

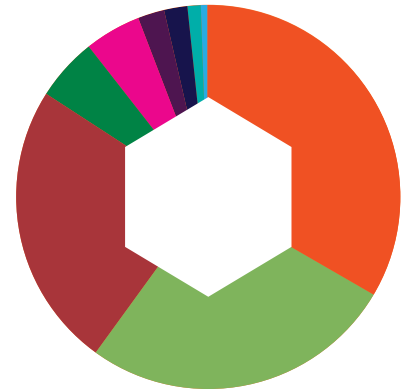
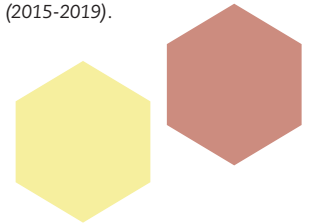


FIGURE 3:
Number of papers by Teagasc and Irish universities that are indexed in Scopus category Food Science (2015-2019).



Impact of Teagasc research publications

Máire Caffrey

Teagasc needs to evaluate research outputs to justify investment, guide decisions on the direction of future research, and understand how our performance compares to similar organisations. Funding bodies require data to show return on investment and researchers like to know how their peers rate their outputs. Teagasc monitors its research impact in various ways. We track the number of articles in scientific journals authored by Teagasc researchers, as well as counting citations to those articles by other scientific articles. There are a number of resources available providing these citation counts and other metrics. Teagasc now uses Scopus, and its accompanying research evaluation tool SciVal. Scopus is an online subscription-based indexing service, which enables exploration of the scientific literature, as well as counting citations to each indexed article. SciVal is a research evaluation tool that allows an organisation to analyse institutional productivity and benchmark outputs. When using publications counts or citation-based metrics, comparisons within subject categories are the most meaningful. To place our performance in a national context, we can compare

Teagasc’s performance with that of the eight Irish universities, within three relevant subject categories: (a) the broad category of Agricultural and Biological Sciences, which is much broader than agricultural research; and, two narrower categories (b) Agronomy and Crop Science, and (c) Food Science.

Considering articles published in the period 2015 to 2019 and indexed in Scopus, we can make the following comparisons:

- Within category (a) Agricultural and Biological Sciences: Teagasc consistently published the second highest number of articles in this category (Figure 1), and had the third highest total number of citations. This is a very satisfactory performance given that Teagasc publications are agriculture related, whereas the other institutions publish in a much broader range of disciplines and agriculture is just a part of their publications in this category.
- Within category (b) Agronomy and Crop Science: Teagasc consistently produced the highest number of publications in this category (Figure 2), and had the highest total number of citations.
- Within category (c) Food Science: Teagasc consistently produced the highest number of publications in this category (Figure 3), and had the second highest total number of citations.

Of course, all bibliometric analysis must be placed in context and the impact of our research must be evaluated in a variety of other ways in order to give the full picture. The examples of research impacting on practice or policy in this publication are one way of outlining impact.



Teagasc Research Programmes

Teagasc’s mission is to support science-based innovation in the agri-food sector and wider bio-economy that will underpin profitability, competitiveness and sustainability.

This is achieved through the close coupling of research and knowledge transfer in four programme areas:

- Animal & Grassland Research and Innovation;
- Crops, Environment and Land Use;
- Food; and,
- Rural Economy and Development.

Animal & Grassland Research and Innovation Programme Departments

- Animal & Bioscience Research
- Grassland Science Research
- Livestock Systems Research
- Pig Development
- Dairy Knowledge Transfer
- Drystock Knowledge Transfer

Locations:

- Athenry, Co Galway
- Grange, Dunsany, Co Meath
- Moorepark, Fermoy, Co Cork

Crops Environment and Land Use Programme Departments

- Crops Research
- Environment, Soils and Land Use Research
- Forestry Development
- Horticulture Development
- Agricultural Catchments
- Crops Knowledge Transfer
- Environment Knowledge Transfer

Locations:

- Johnstown Castle, Co Wexford
- Oak Park, Co Carlow
- Ashtown, Dublin 15

Each of these programmes is composed of research, development and knowledge transfer/industry development departments, as outlined below. Research is conducted at six dedicated locations, while knowledge transfer professionals are located throughout the country (see map on back cover).

Our annual research portfolio comprises over 400 research projects carried out by 800 scientific technical and other support staff and Walsh Fellow graduate students in our research centres throughout Ireland.

In order to maximise the impact of our research, Teagasc actively collaborates with research organisations across the world. This collaboration stretches from individual projects and publications right up to formal alliances and partnerships.

Food Programme Departments

- Food Biosciences Research
- Food Safety Research
- Food Chemistry & Technology Research
- Food Industry Development
- Food Quality & Sensory Science Research

Locations:

- Ashtown, Dublin 15
- Moorepark, Fermoy, Co Cork

Rural Economy and Development Programme Departments

- Agricultural Economics and Farm Surveys Research
- Spatial Analysis, Food Marketing and Agri-Innovation Research
- Farm Management and Rural Development
- Knowledge Transfer

Locations:

- Ashtown, Dublin 15
- Athenry, Co Galway



- ◆ Head Office, Research Centre and Advisory
- ◆ Research Centre and Advisory
- ◆ Advisory Centre
- ◆ Research Station
- ◆ Teagasc College and Advisory
- ◆ Private College
- ◆ Planned Closure



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