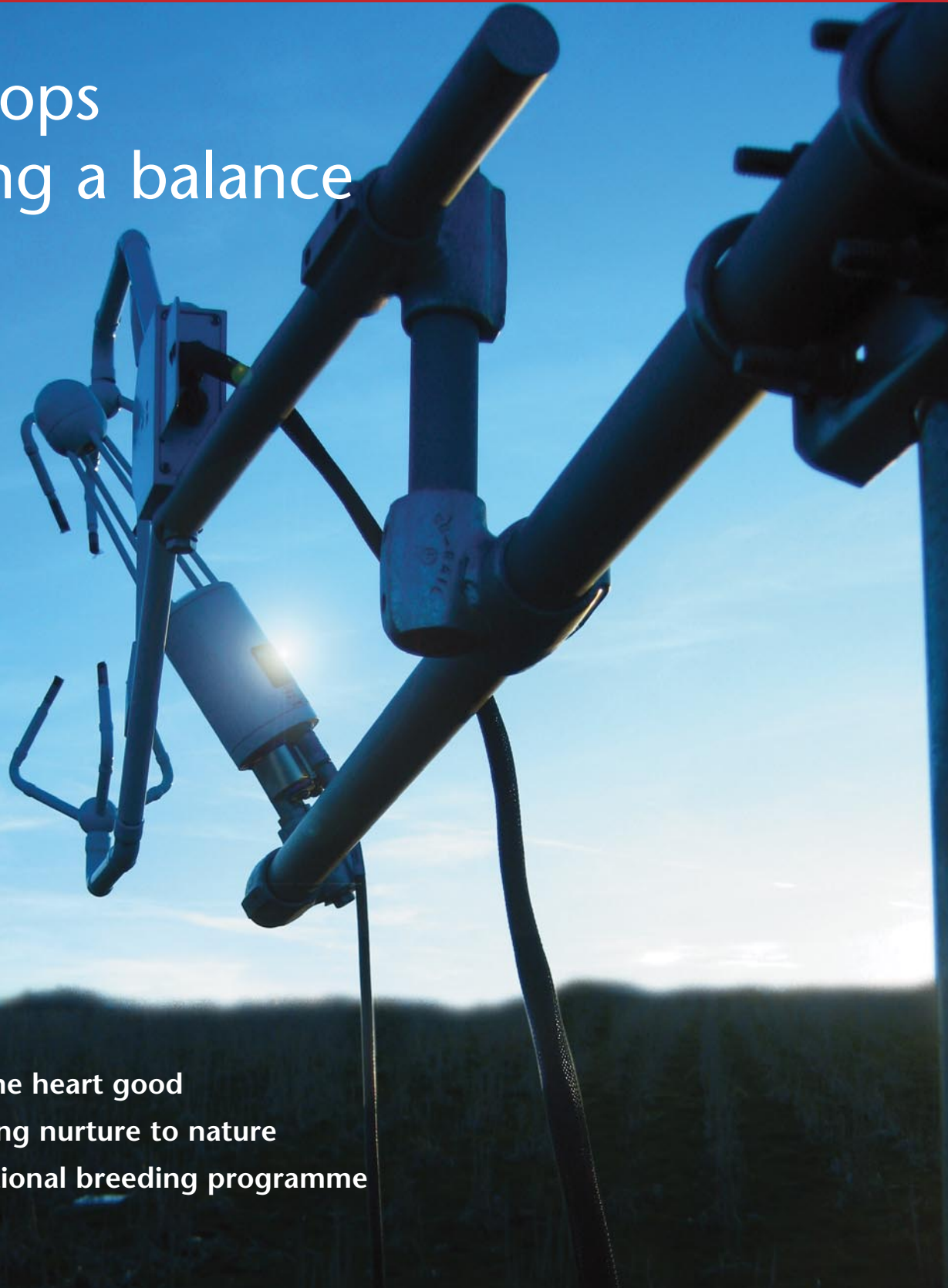


# T Research

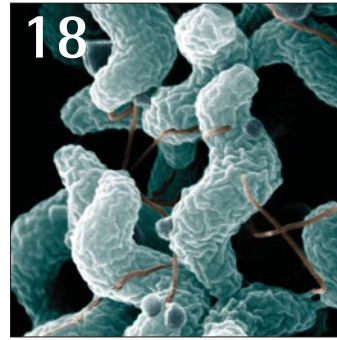
Research and innovation news at Teagasc

Energy crops  
– achieving a balance

- Seaweed – does the heart good
- Epigenetics – linking nurture to nature
- Improving the national breeding programme



# T Contents



<b>News</b>	<b>4</b>
Walsh Fellowships 2012 call	
Teagasc researchers receive SFI Research Frontiers funding	
Potato Genome Sequencing Consortium in <i>Nature</i>	

## T Feature

Research 2.0	8
Irish dairying – planning for 2015	10

## T Crops, Environment and Land Use

Energy crops – achieving a balance	12
Every compaction has an equal and opposite reaction	14
Pesticides from plants	16

## T Food

Antibiotic resistance in <i>Campylobacter</i>	18
Seaweed – does the heart good	20
Thermal analysis of foods	22

## T Animal production and grassland

Epigenetics – linking nurture to nature	24
Soiled water – a valuable resource	26
Improving the national breeding programme	28
Quantifying and understanding tail biting in pigs	30

## T Rural Economy and Development

Measuring up for innovation	32
Territorial cohesion: implications for agriculture policy in the EU	34

<b>Events</b>	
Teagasc science events 2011-2012	36

## T Credits

**TResearch**  
Teagasc | Oak Park | Carlow



*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.

[www.teagasc.ie](http://www.teagasc.ie)

© Articles and images cannot be reproduced without the prior written consent of the Editor. Please note images may have been obtained from an independent source. Please quote *TResearch* when using direct quotes from articles.

**EDITOR** *Catriona Boyle* 059-918 3419 [catriona.boyle@teagasc.ie](mailto:catriona.boyle@teagasc.ie)

## Reaping the rewards of previous investments

Teagasc's research programme is funded by a mixture of grant-in-aid from the Department of Agriculture, Fisheries and Food (DAFF), and external funding, which is awarded on a competitive basis. This year has seen a major increase in awards from two sources. Research funding from the European Union's 7th Framework Programme (FP7) has trebled, from an average of €1 million in 2008 and 2009, to €3.25 million this year. Meanwhile, the value of 'Innovation Partnerships' undertaken by Teagasc has increased from €85,000 in 2010 to €613,000 in 2011.

Success in competing for European funding means that Irish agriculture and food research is judged to be among the best in Europe. This reputation is essential in attracting investment and talent to Ireland. In addition, working in collaboration with our European peers allows Teagasc researchers to address grand challenges such as food security and climate change, which cannot be adequately addressed at a national level.

Innovation Partnerships are collaborative projects between Teagasc and Irish-based companies. Funded by Enterprise Ireland, the aim is to develop new and improved products, processes and services, thereby improving the companies' competitiveness. The seven-fold increase in value of Innovation Partnerships, coupled with the recently announced Dairy Innovation Centre, highlights the relevance of Teagasc research to industry and our focus on building a knowledge-based bioeconomy. Neither of these achievements would have been possible without the consistent investment that the Government – principally through DAFF, but also through Science Foundation Ireland, Enterprise Ireland, IRCSET and the Environmental Protection Agency – has made in Teagasc over the last ten years. These investments have allowed Teagasc to recruit excellent researchers, to build expertise and to improve infrastructure. All of these have been vital in delivering research-based innovation to Irish industry and in competing for research funding at the highest level in Europe. Interestingly, 75% of the funding won under FP7 this year was by researchers recruited in the last ten years. In these difficult times, it is essential to continue supporting Irish researchers, so that they can enhance Ireland's reputation as a research hub and support innovation in Irish-based industry.



**Dr Raymond Kelly**  
Research Support Officer

## Leas a bhaint as torthaí na n-infheistíochtaí roimhe seo

Tá clár taighde Teagasc á mhaoiniú le meascán de dheontas i gcabhair ón Roinn Talmhaíochta, lascaigh agus Bia (RTIB) agus de mhaoiniú seachtrach, rud a bhronntar ar bhonn iomaíoch. Tá méadú mór ann i mblíana ar dhámhachtainí ó dhá fhoinse. Tá an maoiniú taighde ó 7ú Creatchlár (FP7) an Aontais Eorpaigh tar éis méadú faoi thrí, ó mheán €1 milliún i rith 2008 agus 2009 go €3.25 milliún i mblíana. Idir an dá linn, tá luach na 'gComhpháirtíochtaí Nuálaíochta' atá tionscanta ag Teagasc tar éis méadú ó €85,000 i rith 2010 go €613,000 i rith 2011.

Ciallaíonn an rath ar dhul in iomaíocht le haghaidh maoiniú Eorpach go meastar taighde talmhaíochta agus bia na hÉireann a bheith ar na cinn is fearr san Eoraip. Tá an cháil seo riachtanach chun infheistíocht agus tallann a mhealladh go hÉirinn. Chomh maith leis sin, ligean obair i gcomhar lenár bpariaí Eorpacha do thaighdeoirí Teagasc díriú ar dhúshláin mhóra, amhail slándáil bia agus athrú aeráide, ar ceisteanna iad nach féidir díriú orthu go himleor go náisiúnta amháin.

Is tionscadail chomhoibríochta iad Comhpháirtíochtaí Nuálaíochta idir Teagasc agus comhlachtaí atá bunaithe in Éirinn. Agus iad á mhaoiniú ag Fiontraíocht Éireann, is é is aidhm dóibh ná táirgí, próisis agus seirbhísí a fhorbairt, idir nua agus fheabhsaithe, rudaí a fheabhsóidh iomaíochas na gcomhlachtaí. Leagann an méadú faoi sheacht ar luach na gComhpháirtíochtaí Nuálaíochta in éineacht leis an Ionad Nuálaíochta Déiríochta a fógraíodh le déanaí, leagann siad béim ar bhainteacht thaighde Teagasc le tionscal agus ár bhfócas ar thógáil bithghilleagair atá bunaithe ar fhaisnéis.

Ní fhéadfaí ceachtar de na gaiscí seo a dhéanamh gan infheistíocht chomhsheasmhach an rialtais – go háirithe tríd an RTIB, ach trí Fhionduireacht Eolaíochta Éireann, Fiontraíocht Éireann, IRCSET agus an Ghníomhaireacht um Chaomhnú Comhshaoil chomh maith – in Teagasc le deich mbliana anuas. Tá na hinfeistíochtaí seo tar éis ligean do Teagasc taighdeoirí den scoth a earcú, saineolas a thógáil agus an bonneagar a fheabhsú. Bhí na nithe seo go léir rithábachtach i soláthar nuálaíochta atá bunaithe ar thaighde do thionscal na hÉireann agus i ndul san iomaíocht le haghaidh maoiniú taighde ar an leibhéal is airde san Eoraip. Is díol suime é go raibh 75% den taighde a buadh faoi FP7 i mblíana buaite ag taighdeoirí a earcaíodh le deich mbliana anuas.

Agus deacrachtaí eacnamaíochta ann, tá sé riachtanach leanúint de thacú le taighdeoirí na hÉireann, ionas go mbeidh siad in ann cáil na hÉireann mar mhól taighde a fheabhsú agus le tacú le nuálaíocht i dtionscail atá bunaithe in Éirinn.

**An Dr Raymond Kelly**  
Oifigeach Tacaíochta Taighde

### EDITORIAL STEERING GROUP

<i>Catriona Boyle</i>	<i>Owen Carton</i>	<i>Eric Donald</i>	<i>Niall Farrelly</i>
<i>Helen Grogan</i>	<i>Tim Guinee</i>	<i>Richard Hackett</i>	<i>Maeve Henchion</i>
<i>Tim Keeley</i>	<i>John Mee</i>	<i>Dermot Morris</i>	<i>Paul O'Grady</i>
<i>Edward O'Riordan</i>	<i>Rogier Schulte</i>	<i>Declan Troy</i>	<i>Miriam Walsh</i>



Be social! Connect with Teagasc [http://www.teagasc.ie/news/social\\_media.asp](http://www.teagasc.ie/news/social_media.asp)

Reference to any commercial product or service is made with the understanding that no discrimination is intended and no endorsement by Teagasc is implied.

Published on behalf of Teagasc by

**ThinkMedia**  
PROFESSIONAL PUBLISHING SERVICES

The Malthouse, 537 NCR, Dublin 1.

T: 01-856 1166 F: 01-856 1169 [www.thinkmedia.ie](http://www.thinkmedia.ie)

Design: Tony Byrne, Tom Cullen and Ruth O'Sullivan

Editorial: Ann-Marie Hardiman and Paul O'Grady

## Researcher profile



### Dr Rogier Schulte

Rogier is Head of Teagasc's Environment, Soil and Land Use Research Department, at Johnstown Castle in Wexford. He oversees a wide programme area that includes nutrient efficiency, water quality, greenhouse gases, soil quality and biodiversity. In addition, as chair of Teagasc's Working Group on Greenhouse Gas Emissions and former chair of the Working Group on the Water Framework Directive, he is responsible for integrating environmental knowledge and expertise from across the organisation. In this capacity, he recently compiled two major reports on the role of agriculture in protecting water quality and combating climate change, in response to government consultations.

Rogier's background is in environmental modelling, and he has developed mathematical models on soil moisture conditions, grass growth and nutrient utilisation and losses. Rogier obtained his BSc and MSc in Biology from Wageningen University in the Netherlands in conjunction with NUIG. He continued his studies as a Teagasc Walsh Fellow at Johnstown Castle, and was awarded a doctorate degree in 2000 as well as the title 'Teagasc Young Researcher of the Year 1999'. In 2000 he commenced as a Research Officer at Johnstown Castle, before taking up his current position in 2005.

Rogier has initiated a number of large-scale projects, including the Irish Soil Information System (ISIS), which is currently developing a 1:250,000 soil map of Ireland that will supersede the well-known current General Soil Map. Says Rogier: "People ask me if I am an agricultural scientist or an environmentalist. I'm neither. Or both. My interest is natural resource management. Basically, we have a limited amount of resources in the world, whether it's soil, air, water, nature or fossil fuels, and at the same time there are a lot of people in the world, all of whom have the right to proper nutrition. The trick is to make both ends meet, economically and environmentally, for the present generation, and for future generations. That is what drives me, to make that work for Irish agriculture. Recently, I have taken an interest in pursuing the same goals in overseas development.

"What I enjoy most about my job is the variety of people I get to work with. There is so much talent across Teagasc, and I have the luxury of working with different experts every day. And one day I can be standing in a field discussing nutrient management with farmers, the next day I can be in Brussels or Paris giving the same talk to EU policy makers. That is what I love about Teagasc, and something that would be hard to find in any other organisation.

"My leisure pursuits include perusing the local beach, playing with my camera, singing in Wexford's Vocare mixed choir, all things outdoorsy and travelling, travelling, travelling. In a different life, I would have been an explorer."

## Walsh Fellowships 2012 call

The Walsh Fellowships Scheme provides fellowships to postgraduates to work on research projects relevant to the Teagasc Research Programme while studying for a higher degree. Applications for Fellowships are made by full-time academic staff in third-level colleges in collaboration with a Teagasc Research Officer. The successful applicants select the Walsh Fellows. Teagasc now invites applications from academic staff at third-level colleges for its 2012 Scheme. Applications are invited on any aspect of the Teagasc Research Programme in: Food; Animal (including Pigs) & Grassland; Crops, Environment and Land Use; and, Rural Economics and Development. A complete listing of Teagasc topic areas is available on the Teagasc website – [www.teagasc.ie/research/postgrad/2012/wf\\_scheme\\_2012.asp](http://www.teagasc.ie/research/postgrad/2012/wf_scheme_2012.asp). Completed electronic (Word) application forms with the electronic signatures of both applicants must be emailed to [walshfellowships@teagasc.ie](mailto:walshfellowships@teagasc.ie) by 5.00pm on Friday, September 23, 2011.

## Teagasc researchers receive SFI Research Frontiers funding

The Minister for Research and Innovation, Mr Seán Sherlock TD, recently announced Government funding of €15 million to be provided over the next four years for 79 research projects as part of Science Foundation Ireland's 2011 Research Frontiers Programme.

Teagasc has two projects to be funded under this Programme, from Dr Kieran Meade and Dr Ewen Mullins.

Dr Kieran Meade, Teagasc Animal Biosciences Centre, Grange, Co Meath, received funding for 'Distinct Interleukin-8 promoter haplotypes – functional implications for expression, neutrophil recruitment and *Staphylococcus aureus* survival in cattle'.

"The Interleukin-8 (IL-8) protein is key to mediating successful immunity. It functions by attracting cells and activating them to kill bacteria. We found variants in the gene that encodes this protein, which are variable between cattle breeds and could confer immunological differences. We aim to characterise the functional variants of the IL-8 gene. Exploiting these differences will allow us to breed animals with better immunity, thus reducing infectious disease on farms, antibiotic use and contamination of the food chain," said Dr Meade.

Dr Ewen Mullins, Teagasc Crops, Environment and Land Use Research Centre, Oak Park, Carlow, received funding for 'Developing a novel technology platform for the genetic transformation of plant and fungal cells'.

"The bacterium *Agrobacterium* is the most favoured tool used in biotechnology for genetically improving an organism's performance. Unfortunately for end users of *Agrobacterium*, capitalising on outputs from their research is unfeasible due to restrictive licensing conditions. We have developed a novel alternative (EMT) that is as efficient as *Agrobacterium* and bypasses existing patents. In this project we will test the adaptability of EMT on a wider range of organisms, determine how accurate EMT can be in transferring DNA, and further improve the efficacy of EMT, enhancing its potential as a competitive alternative to *Agrobacterium*," explains Dr Mullins.

## Potato genome sequence

The Potato Genome Sequencing Consortium (PGSC), an international team of scientists – with Teagasc representing Ireland – whose goal was to develop a high-quality draft sequence of the potato genome, recently published its findings in the prestigious international journal *Nature*. The PGSC was initiated in January 2006 by the Plant Breeding Department of Wageningen UR (University & Research Centre) in the Netherlands and, during the course of the project, developed into a global consortium of 29 research groups from 14 countries. The Teagasc group, led by geneticist Dr Dan Milbourne of the Crops, Environment and Land Use Research programme, based at Oak Park in Carlow, was among the earliest members of the consortium.



*The Potato Genome Sequencing Consortium team at Teagasc Crops, Environment and Land Use Research Centre, Oak Park, Carlow (from left): Dr Istvan Nagy; Dr Dan Milbourne; and, Teagasc Walsh Fellow Marilaura Destefanis.*

## Health and Safety



*Pictured at the Agricultural Occupational Safety and Health Conference (from left): Dr Catherine Blake, School of Physiotherapy and Performance Science, UCD; David Meredith, Rural Economy Development Programme, Teagasc; Professor James Phelan, Dean, Agriculture and Food Science, UCD; and, Aoife Osborne, Teagasc/HSA Walsh Fellow on Occupational Health.*

## EuroFoodChem success



Ciarán FitzGerald was awarded the best poster accolade at EuroFoodChem XVI in Poland recently for his submission, which was entitled: 'Isolation of heart healthy peptides derived from *Palmaria palmata* and incorporation of these peptides in bread! Ciarán is fully funded by the Teagasc Walsh Fellowship Scheme and is carrying out his PhD studies under the supervision of Drs Maria Hayes and Eimear Gallagher at the Teagasc Food

Research Centre, Ashtown, as well as with his university supervisor, Dr Deniz Tasdemir from the Department of Pharmaceutical and Biological Chemistry, School of Pharmacy, University College London. The EuroFoodChem series of conferences is the flagship of the Division of Food Chemistry of the European Association of Chemical and Molecular Sciences, and this year the conference was supported by the EU FP7 Project: 'Unlocking the potential of the Institute of Animal Reproduction and Food Research for strengthening integration with the European Research Area and regional development'.

## Dr Anne Baily

Dr Anne Baily, at 68, is Teagasc's most senior Walsh Fellow to date and has demonstrated how it is possible both personally and within an institutional framework to aim high, and develop new and important scientific knowledge to support the sustainable



growth of Irish agriculture. Based at the Johnstown Castle Environment Research Centre, Anne recently graduated with a PhD from Queen's University Belfast, investigating nitrogen losses from the Johnstown dairy farm to the atmosphere and groundwater, and the part played by denitrification. Her supervisors were: Dr Hubert Tunney and Professor Phil Jordan at Teagasc; Professor Chris Elliott at Queen's University Belfast; and, Dr Catherine Watson at the Agri-Food and Biosciences Institute in Belfast.

Anne's work investigated denitrification in grazed grassland soils and in groundwater as determined from intensive field and laboratory experiments: the rate and magnitude of nitrous oxide emissions from fertilised grassland; the influence of grazing intensity on both benign dinitrogen and potent nitrous oxide gas emissions using isotopic labelling techniques; and, identifying nitrate sources and denitrification processes in shallow groundwater using the stable isotopes of nitrate. Anne summarised the implications of her work: "Denitrification in agricultural soils and groundwater is a nitrogen loss process with environmental, political, economic and management implications. Understanding where, when, why and how much nitrogen is denitrified could create a basis for increasing nitrogen use efficiency, an essential part of agricultural sustainability".

The three parts to the project are either in review or final preparation for publication in the international literature.

## Toxin-producing bacteria

A better understanding of how bacterial toxins cause common human diseases may lead to improved disease treatment and prevention, according to a paper just published by Irish and US scientists in *Nature Reviews Microbiology*. Scientists discuss the identification, genetics and biochemistry of streptolysin S (SLS), a bacterial toxin produced by the bacteria *Streptococcus pyogenes*. *S. pyogenes* causes a wide variety of infections of the upper respiratory tract and skin, with complications leading to invasive diseases such as the 'flesh-eating' skin disease necrotising fasciitis, and streptococcal toxic shock syndrome. As a consequence of these diseases, and other auto-immune complications like acute rheumatic fever and subsequent rheumatic heart disease, up to half a million deaths per year worldwide are attributed to *S. pyogenes* infections. Further research into this group of toxins will lead to the identification of novel targets for antibiotic and vaccine development for the treatment and prevention of human disease.

Lead author of the review, Evelyn M Molloy, is a PhD student in microbiology at the Alimentary Pharmabiotic Centre, UCC, under the supervision of Paul Cotter, Colin Hill and Paul Ross. The research involves collaboration between the researchers at the Alimentary Pharmabiotic Centre based in UCC and Teagasc Moorepark Food Research Centre, along with colleagues at the University of Illinois at Urbana-Champaign, USA.



Lead author of the review, Evelyn M. Molloy, a PhD student in microbiology at the Alimentary Pharmabiotic Centre, UCC, with supervisor Dr Paul Cotter, Teagasc Moorepark Food Research Centre.

## Willow is the ANSWER

Teagasc is to participate in the Agricultural Need for Sustainable Willow Effluent Recycling (ANSWER) project, which recently received funding from the European Union's European Regional Development Fund.

ANSWER has eight cross-border partners. AFBI is the lead partner who will supervise, in conjunction with Queen's University Belfast, three postgraduate studentships. Teagasc will conduct research on the impacts of applying effluent to willow.

IT Sligo will supervise a Masters student working on the impacts on biodiversity of irrigating effluent to willow. South West College (Cookstown Campus) will be applying GIS (geographic information systems) technologies to map opportunities for effluent irrigation.

NIWater will have two major sites, while Monaghan and Donegal County Councils will have one site each in which significant areas of willow will be irrigated with municipal effluent. Cookstown District Council will be investigating the use of SRC willow for the disposal of landfill leachate.



The ANSWER Project Partners. Front row (from left): Alistair McCracken, AFBI – Lead Partner; Karen McDowell, NIWater; and, Ann-Marie Duddy, IT Sligo. Back row (from left): David Richardson, Cookstown District Council; Declan Ryan, Teagasc; Aaron Black, South West College; Mark Johnston, Monaghan County Council; and, Com McLaughlin, Donegal County Council.

## New dairy innovation centre

Teagasc and The Irish Dairy Board (IDB) have created a new Dairy Innovation Centre based in Teagasc Moorepark. The objective is to develop market-led product concepts that can be manufactured by IDB members and marketed internationally by the IDB. The initiative is a response to the IDB's medium-term plans to maximise the expansion opportunities that will be created for the Irish dairy sector when the European Union abolishes milk quotas in 2015 and the Government's *Food Harvest 2020* Report. This partnership is a vital part of the IDB's strategy to increase the added value element of Irish dairy exports, and Teagasc's strategy to support innovative research by commercial Irish food companies.



Professor Paul Ross, Head of Food Programme, Teagasc, Dr Diarmuid Sheehan, Programme Manager, Dairy Innovation Centre, and Karen Thompson, Innovation & Strategy Manager, Irish Dairy Board, are pictured at the launch of the Irish Dairy Board Dairy Innovation Centre located at the Teagasc Food Research Centre, Moorepark.

## Agricultural catchment visit



Pictured on a visit to the Teagasc Agricultural Catchment in Timoleague to launch the Catchment Science 2011 conference, which takes place in the Mansion House, Dublin, from September 14 to 16, are (from left): landowner Kevin Collins, Timoleague; Ger Shortle, Teagasc; Mr Simon Coveney, Minister for Agriculture, Food and the Marine; Professor Gerry Boyle, Director, Teagasc; and, landowner Colin Bateman, Timoleague.

Teagasc event proceedings and presentations can be found online at [www.teagasc.ie/publications](http://www.teagasc.ie/publications).

## Minister welcomes FP7 success



The Minister for Agriculture, Food and the Marine, Simon Coveney, TD, has said that he was delighted to learn that a number of researchers from Irish research institutes and agri-food SMEs are participants in successful consortia to be funded under the EU's 2010 Research Call under the Seventh Framework Programme for Research and Technological Development (FP7). Irish researchers are involved in 20% of the recent awards by the EU Commission in the Theme Area covering Food,

Agriculture & Fisheries, and Biotechnology. The value of funding to Irish researchers is in excess of €6.1 million.

The successful applicants included Teagasc, the Marine Institute, University College Dublin, Trinity College Dublin, University College Cork, and Limerick Institute of Technology. "It is important for Irish researchers to participate in European collaborative programmes," the Minister said, "and this recent success indicates the high quality of research being conducted at Irish research institutes". He congratulated in particular Dr Susanne Barth of Teagasc (pictured), who is leading a research team from 10 countries on a project to enhance biomass production from marginal lands with perennial grasses. Minister Coveney went on to acknowledge the ongoing success of Irish researchers, who have secured over €20.3 million in research funding to date under FP7 since 2007. The Minister added that "the level of funding secured is very significant and a clear demonstration of the essential need to continue Ireland's investment in R&D, particularly in relation to our most important indigenous sector and especially given the economic challenges facing both the country and the industry".

## Visiting postdoc



Pictured are Dr Maria Hayes, Teagasc Food Research Centre, Ashtown, with visiting postdoctoral researcher Dr Leticia Mora Soler.

Dr Leticia Mora Soler received the Fundación Alfonso Martín Escudero postdoctoral fellowship in 2010 to conduct research at Teagasc Food Research Centre, Ashtown, with Dr Maria Hayes and Declan Troy. The project Leticia worked on examined the potential of waste and by-products from fish and meat processing as sources of bioactive compounds for use in functional foods. This is a topic of great interest to both the marine and meat processing industries in Ireland. Sustainable food production and waste valorisation are becoming important issues in the food industry, where high amounts of biological by-products and waste are generated.

# Research 2.0

Social media have transformed the way people use the internet. CATRIONA BOYLE summarises a new guide that explains how researchers can get the most out of their networks.

The idea of being a participant in a community is very important in social media (and also in academic discourse). A bewildering array of online media now exists that seeks to create and administer these communities, and many can have real benefits for academic researchers, if they can learn how best to use them.

## Research Information Network

To help researchers get the most out of their networks using these online tools, the Research Information Network in the UK has produced a useful guide – 'Social Media: A guide for researchers'. According to the guide: "One of the most important things that researchers do is to find, use and disseminate information, and social media offer a range of tools which can facilitate these activities". It discusses the use of social media for research and academic purposes, rather than the many other uses that they are put to across society.

Participating in social media does not necessarily mean that you have to be a major producer of content. Your participation could be limited to tagging or 'liking' a resource, or responding to someone else via a microblog (such as Twitter) or social networking tool (such as Facebook). At the other end of the scale, some of the most active users of social media produce large amounts of content every day, including posting datasets, writing analyses or comments, or sharing bibliographic data.

## Social and professional networking tools

Social networking services such as Facebook are probably what most people think of when they think about social media. Social networking tools enable groups of people to communicate, store details about each other, and publish information about themselves.

Each social networking service is different, offers different functionality and, perhaps most importantly, has its own culture. LinkedIn is used mainly for professional networking. It is more popular in business than in academia but offers a range of functionality that suggests it may be useful for researchers.

But cultures grow and change in response to how participants use the service. There have been a number of attempts to launch social networks focused on the needs of researchers. To date, none has become an obvious market leader, and researchers remain scattered across a range of social networking services. Researcher-specific social networking services include ResearchGate, GraduateJunction, MethodSpace and Nature Network.



Social and professional networking tools nevertheless offer a range of opportunities to researchers. Perhaps first and foremost they provide a way to keep track of people connected to you professionally. If you become an active user they can also offer opportunities to build and maintain professional relations and provide a forum for collaboration.

## Social bookmarking

Social bookmarking sites allow users to store, tag, organise, share and search for bookmarks (links) to resources online. Tagging bookmarks with appropriate terms means that they can easily be found again without the need to search for precise words. Unlike file sharing, the resources themselves are not redistributed, only bookmarks that point to their location. Such websites are an extension of bookmark files in web browsers, but have many advantages over browser-linked information. The information is available from any browser and is automatically backed up for security. Many websites offer the opportunity to tag pages to social bookmarking services by clicking on icons at the bottom of the page. Most social bookmarking tools also allow you to insert a button directly into your browser for easy tagging. Different bookmarking tools include Delicious, Diigo and BibSonomy.

## Social citation sharing

Social citation-sharing tools are designed specifically to enable researchers to manage their references and to share information about what they are reading. They are first and foremost reference management systems, and share many features with social bookmarking tools. However, they are specifically designed to be used by researchers and other information professionals.

They allow you to store, organise and retrieve references and notes about literature you have read or seen. In addition to a traditional reference management tool, they also offer the ability to connect and share with others. Tools for social citation sharing include CiteULike, Mendeley and Zotero.

## Blogging

A blog is a type of website, or part of one. Usually a blog is maintained by an individual or small group and presents a mix of opinion, news and other types of content. The posts on a blog are usually organised in reverse chronological order so that the first entries you see are the most recent ones.



**Web 2.0** is a term used to describe a new generation of web services and applications with an increasing emphasis on human collaboration.

**Social media** describes the online technologies and practices that people use to share opinions, insights, experiences and perspectives. Social media can take many different forms, including text, images, audio and video. These sites typically use technologies such as blogs, message boards, podcasts, wikis and vlogs to allow users to interact.

**Social networking** is the process of building online communities, often accomplished both through 'groups' and 'friends lists' that allow greater interaction on websites.

Blogs can be used for a wide variety of purposes. At their most basic they can provide you with an easy way to make some of your data or writing available on the web. Most blogs also offer a comment feature and they frequently become temporary forums for discussions prompted by an original post. Blogs can be useful to build your profile as a researcher, provide a vehicle for collaboration and to get ideas. Blogging tools include Blogger, Wordpress and Posterous.

### Microblogging

Microblogs offer a way to make small pieces of writing or data available online. They usually include features that enable you to build up a network of followers or friends. Typically, people provide a single sentence or image as part of a microblog post. As with blogs, however, people can comment on what you have posted, and so microblogs can provide a forum for extended interactions.

Microblogs encourage conversations that would not take place in any other medium. Whereas email generally offers one-to-one communication, microblogs are a many-to-many form of communication. This can create a web of interactions that can initially be confusing to follow.

The challenge with microblogs is getting past the simplicity. Since a microblog will often allow you to share only a sentence or so, it can feel that you can't express yourself in a meaningful way. However, microblogs are frequently used to share links that point towards more substantial resources. Conversation on microblogs is made up of short exchanges, fast flowing and multi-faceted. They often become very busy when news is breaking that matters to your network. Microblog tools include Twitter, Tumblr and Plurk.

### Research and writing collaboration tools

There is a range of tools that enable researchers to collaborate in writing and research tasks. Wikis are websites that allow easy creation and editing of interlinked web pages via a web browser. They are extremely flexible, and so they have been put to a wide range of uses, including community websites, personal note taking, corporate intranets and knowledge management systems. Most wikis allow administrators to adjust access rights to the site or to individual pages, so that they can choose who is allowed to add to or modify the content on the site.

In addition to wikis, other collaborative writing tools are available, including Google Docs, The Zoho Office Suite and Dropbox.

### Project management, meeting and collaboration tools

As mentioned earlier, wikis are often used as project management tools, enabling members of a team to contribute to and receive updates on documentation and progress. Blogs are also sometimes used for this purpose, even if only to document team meetings and disseminate outcomes. There are many more specialised tools, however, which can be grouped under two broad headings: communication tools; and, more specialised project management tools. One of the best-known internet-based communication tools is Skype ([www.skype.com](http://www.skype.com)). In addition to person-to-person IP telephony, Skype also provides screen sharing and group conferences for up to 25 people, with additional features including instant messaging (useful for sharing links), file transfer and video conferencing. The basic computer-based service is free for calls over the internet, but calls to phones incur small charges. These features make Skype a cheap but powerful tool for collaborators working at a distance from each other, or for gathering research data (for example through interviews) without the need to travel. Adobe Connect, Citrix GotoMeeting, Elluminate and DimDim are other such tools.

### Information overload

The social tools mentioned above all provide channels through which new information is being produced every day. For some people this can be overwhelming and lead to a feeling of information overload. However, people typically use social media in a way that uses their social or professional networks to filter the vast array of information down to something that is manageable. Once you have built a network of people with interests similar to yours, you can use them to identify resources that you are likely to be interested in. Social media have the potential to extend your working day and blur the distinction between work and other aspects of your life. Researchers may need to think carefully about boundaries, particularly if they are using mobile devices.

### Privacy

Social media are built on a culture of active personal and professional disclosure. There are concerns about how this is changing the interface between public and private spaces, and about misuse of our data. For researchers, putting your professional life online can feel exposing, particularly if you express opinions and ideas that have not been subject to the normal process of peer review.

Concerns about privacy mean that users of social media need to take care in their approach to disclosure and to understand the legal and policy frameworks that govern the ownership and use of information.

*For links to Teagasc's social media pages see [http://www.teagasc.ie/news/social\\_media.asp](http://www.teagasc.ie/news/social_media.asp).*

### Reference

RIN. (2011). 'Social Media: A guide for researchers'. [www.rin.ac.uk/social-media-guide](http://www.rin.ac.uk/social-media-guide). Also available in hard copy.

**Catriona Boyle** is Teagasc's Scientific Writer/Editor.

E-mail: [catriona.boyle@teagasc.ie](mailto:catriona.boyle@teagasc.ie).



# Irish dairying – planning for 2015

The recent Moorepark Open Day set out the roadmap for the *Food Harvest 2020* target of a 50% increase in milk production. DEIRDRE HENNESSY and JOHN MEE discuss the highlights and present the exit poll findings.

More than 7,000 visitors attended the Moorepark National Open Day 'Irish Dairying – Planning for 2015', sponsored by FBD Trust, on June 29. Visitors met and interacted with researchers and advisers at research stands, themed villages, demonstrations, and at a discussion forum. As quotas are due to be abolished in 2015, the focus of the open day was 'Planning for 2015'. The main stands dealt with developing milk production systems and quota management between now and 2015, grassland management, grass-based animal genetics, getting calving pattern right and animal health. In addition, the latest research from the milk quality and composition, animal breeding, grassland, energy use efficiency, environmental sustainability, and Moorepark food research programmes were presented. A grassland demonstration, in which farmers could actively participate by creating a grass wedge and discussing the actions to be taken with an adviser, proved very popular.

## Planning for 2015

Dairy farmers must develop low-cost grass-based milk production systems to ensure financial viability in a market environment where there is likely to be increased input and output price volatility. Research at Moorepark shows that a seasonal milk supply profile based on spring calving grass-based production systems will result in higher profitability for the whole dairy industry. It is vitally important that all dairy farmers put in place a transition plan so that they are in the best place to expand profitably post quota. Management of quota in the next number of years is critical to ensure that super levy fines do not place financial pressure on farmers. Options for managing quota were presented on the day and included: reduction/withdrawal of supplementary concentrate feed; feeding more milk to calves; purchasing milk quota; reducing milking frequency for part or all of the year; and, reducing lactation length. Priority areas for investment on dairy farms between now and 2015 include breeding high economic breeding index (EBI) replacements; reseeding low producing paddocks; developing efficient grazing structures and labour efficient farmyards; improving herd health status; and, developing grazing management and financial planning skills.

## Grassland management for milk production

Increasing grass utilised per hectare will increase profit per hectare post quotas. Increasing stocking rates in association with an appropriate calving date will increase grass utilisation and milk solids production. Ninety per cent of the feed requirement of the spring calving herd should be produced from either grazed grass or grass silage. Grazing management practices must result in high quality

grass. Key grassland management tools were outlined at Moorepark Open Day. These include: the spring rotation planner to be used for the first rotation; the grass wedge in mid season; and, the 60:40 rule in autumn. Important points presented on the day included ideal post-grazing sward height of 3.5cm in spring; target pre-grazing herbage mass of 1,300-1,600kg DM/ha in mid season; and, closing 60% of the farm by November 7 and the remaining 40% by December 1.

## Grass €calculator

A new tool which allows farmers to calculate the grass utilisation on their farm was launched at the Moorepark Open Day. The Grass €calculator uses milk production, fat and protein content, stocking rate, concentrate supplementation and silage harvested to retrospectively calculate grass utilisation. The Grass €calculator tool is available online at [www.agresearch.teagasc.ie/moorepark](http://www.agresearch.teagasc.ie/moorepark).

## Cow-calf health

Since the last open day in 2009, there have been major developments in animal health at Moorepark and nationally. At Moorepark, a new calf health research programme has commenced on calf survival around birth. This project is working with commercial dairy farmers to understand why some farmers lose more calves than others and what they can do to rectify this. The calf-rearing project at Moorepark has focused on optimising colostrum management, identifying target body weights at weaning and evaluating alternative options for calf housing on expanding dairy farms. The results from these projects are contributing to the Animal Health Ireland (AHI) Technical Working Group (TWG) on Calf Health. The mastitis research project at Moorepark has resulted in the new national mastitis control programme rolled out by AHI; CellCheck (<http://www.animalhealthireland.ie/>). In addition, the herd health project at Moorepark has contributed to the AHI approach to bovine viral diarrhoea (BVD) control. Following industry consultation, a national eradication programme for BVD is planned to commence in 2012. Research and advisory staff in Teagasc are actively involved in the AHI TWGs dealing with prioritising national disease control based on best available science.

## Compact calving pattern

The guidelines for optimal herd fertility were outlined at the open day. Critical management factors are: correct body condition score from the dry period through the breeding season; early identification of non-cycling cows;



Dr John Mee, Teagasc, talks to visitors on 'Achieving a Healthy Herd' at the 'Irish Dairying – Planning for 2015' open day in Moorepark, Fermoy, Co. Cork.

maximising submission rate; and, using reproductive records to identify problem indices. The recommended reproductive calendar consists of four weeks of pre-breeding heat detection, treatment of problem cows at mating start date, six weeks of AI and six weeks of natural service, with pregnancy detection five to seven weeks later. For herds not achieving these targets, recent research at Moorepark has identified substantial benefits from using hormonal programmes. Whole-herd synchrony and timed AI resulted in a higher submission rate and earlier establishment of pregnancy, with a consequent earlier calving pattern in the following season. In addition, the results from a study at Moorepark comparing cows with poor genetic merit for fertility with those of a higher merit have shown that cows with a higher genetic merit for fertility do indeed have substantially better fertility, at the same level of milk solids production. Differences in progesterone concentrations may explain some of this genetic effect.

### Advancing genetic selection

The research on cattle breeding at Moorepark is at the forefront of genetic selection internationally. Since the last open day in 2009, when genomic selection (GS) was launched, the uptake of GS has been strong with GS bulls now accounting for 40% of AI straws. The ICBF now provides a GS service (€50-100), using a calf hair sampling kit, to all dairy farmers. GS is currently undertaken on all traits in the EBI and will soon be available on type traits. Two new European animal breeding projects have recently commenced at Moorepark. The OptiMIR project is using mid-infrared spectrometry (MIR) results for milk constituents to generate usable genetic decision support tools. The GreenhouseMilk project is investigating the influence of genetics on environmental footprint – in particular greenhouse gas emissions and cow production efficiency. In addition, the crossbreeding research work at Ballydague farm is continuing to generate results on crossbreeding, showing that Jersey x Holstein-Friesians are at least as productive, have higher intake capacity, are more efficient converters of grazed grass to milk solids, and are markedly more fertile than Holstein-Friesians.



Pictured in Teagasc Moorepark at the CellCheck stand at the 'Irish Dairying – Planning for 2015' open day are: Professor Gerry Boyle, Teagasc Director; Mike Magan, Chairman, Animal Health Ireland; Dr Pat Dillon, Head of Animal Production & Grassland, Teagasc; Finola McCoy, Programme Manager; John McNamara, Teagasc; and, members of West Cork & Carbery discussion groups (representing the four West Cork co-ops).

### Exit poll

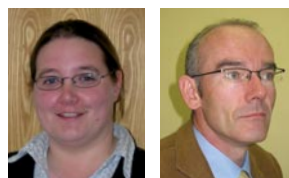
Two hundred people responded to the exit survey. Respondents ranked the event as follows: very beneficial – 52%; helpful – 47%; and, not helpful or beneficial/no opinion/spoilt ballot cards – 1%. Fifty-three percent of respondents came to see all exhibits, with 31% indicating that they came specifically to see one of the first six stands (planning for 2015, profitable dairy systems, turning grass into money, grass-based genetics, calving pattern, and animal health). Individual exhibits that stood out for people were the grassland demonstration, animal health, and planning for 2015.

'Moorepark '11 Irish Dairying – Planning for 2015', the Moorepark Open Day 2011, was sponsored by FBD Trust. The Grass €calculator project was sponsored by Ulster Bank.

### Associated publications

- Buckley, F., (Ed.).** (2011). 'Moorepark '11 Irish Dairying – Planning for 2015'. Teagasc: Moorepark Animal & Grassland Research and Innovation Centre, 142 pages [online], available from [www.teagasc.ie/publications](http://www.teagasc.ie/publications).
- McCarthy, B., Shalloo, L. and Geary, U.** (2011). 'The Grass €calculator'. Teagasc: Moorepark Animal & Grassland Research and Innovation Centre, 22 pages [online], available from [www.agresearch.teagasc.ie/moorepark](http://www.agresearch.teagasc.ie/moorepark).

**Dr Deirdre Hennessy** is a Research Officer and **Dr John Mee** is a Principal Research Officer in Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark. E-mail: [deirdre.hennessy@teagasc.ie](mailto:deirdre.hennessy@teagasc.ie).



## Energy crops – achieving a balance

Meeting renewable energy and co-firing targets will require the conversion of land for energy crop cultivation. Teagasc is quantifying the greenhouse gas emissions associated with these crops.

The European Union has ambitiously committed to increase the proportion of renewable energy from 9% today to 20% of total energy consumption by 2020 (EU, 2009). Bioenergy feedstock consists of agricultural residues (e.g., straw) and specifically cultivated crops (e.g., hybrid poplar [*Populus* spp.], willow [*Salix* spp.], miscanthus [*Miscanthus* spp.], reed canary grass [*Phalaris arundinacea*] and maize [*Zea mays*]), and these are expected to play an important role in meeting European greenhouse gas (GHG) reduction targets. In Ireland, the three peat-burning power stations will be obliged to co-fire with 30% biomass by 2015–2017. While forestry thinnings are currently providing much of the feedstock, there may be a requirement to convert as much as 60,000 hectares to biomass cultivation to meet this target.

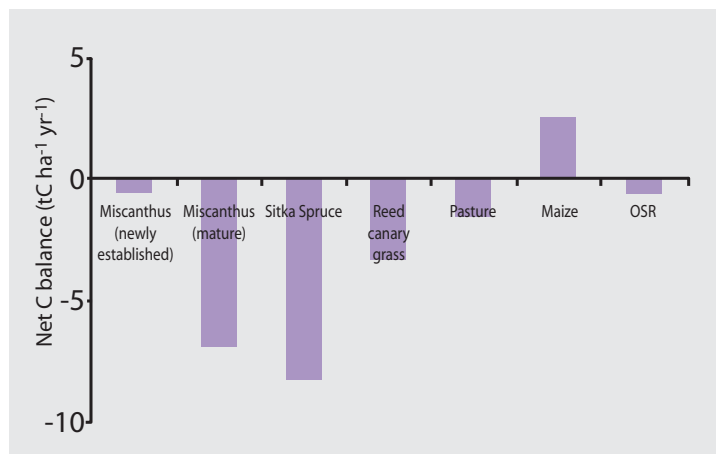


FIGURE 1: Net carbon balance of various land use types. Negative values indicate net carbon uptake, while positive values indicate net carbon emissions.



Eddy covariance tower measuring field-scale CO<sub>2</sub> fluxes over a reed canary grass stand at Johnstown Castle.

Land use change to biomass production can contribute towards meeting both national and international renewable energy and emissions targets. Already, land use change to forestry (LULUCF – Land use, land use change and forestry as defined by the UN) offsets almost 1.5 million tonnes of emissions per annum (Duffy *et al.*, 2011) and the conversion of pasture or annual cropland to perennial biomass crops and/or short rotation coppice (SRC) also has the potential to become a significant contributor to meeting future GHG targets. However, realisation of this mitigation potential is dependent on: a) the conversion of a substantial portion of land to biomass; b) selection of suitable crop types; c) development of reliable combustion systems; and, d) rigorous measurement of emissions and carbon sequestration during cultivation.

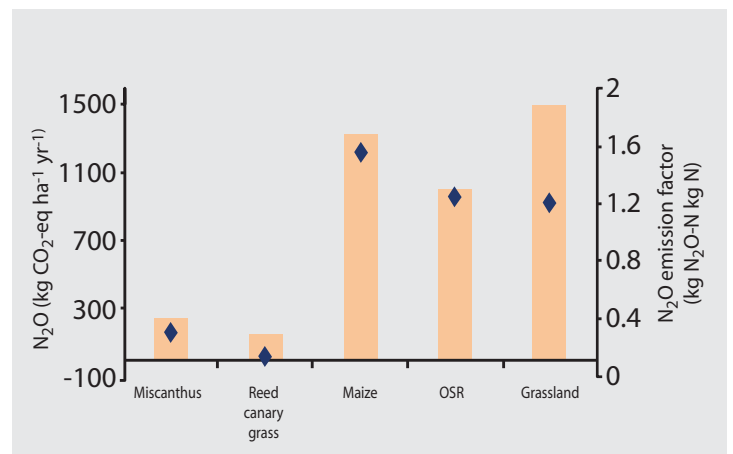


FIGURE 2: Nitrous oxide emissions (expressed as kg CO<sub>2</sub>-equivalents) and N<sub>2</sub>O emission factors for various land use types.

## Role of biomass in GHG mitigation

Bioenergy crops can mitigate GHG emissions in three ways:

### Carbon sequestration

GHG emissions can be reduced by storing a proportion of carbon captured by photosynthesis in the soil or woody biomass (carbon sinks). These sinks can be either perennial woody tissue or soil organic carbon (SOC). Sequestration occurs when the input of carbon dioxide is greater than removals from harvesting and decomposition. The extent to which perennial biomass crops increase carbon sequestration will depend on the land use being replaced (Figure 1). In the case of arable displacement, there will be a net increase in carbon sequestration (Figure 1). Most of this carbon loss is assumed to be associated with both ploughing and extended fallow periods. Overall carbon input into the soil associated with the conversion of arable land to biomass has been estimated to increase by 2.8–4.1 tCO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup> for miscanthus and 1.8–2.7 tCO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup> for SRC. It should be noted that, in order to reach these rates of sequestration, it may take two to three years post establishment of the crop.

The conversion of pasture to biomass crops (miscanthus or SRC) was assumed to have no impact on long-term net carbon sequestration. Indeed, in the short term, losses of 2–4 tCO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup> may be associated with ploughing. However, recent measurements under a range of soil types have shown that initial carbon loss after ploughing is much lower than first thought (less than 1 tCO<sub>2</sub> ha<sup>-1</sup> yr<sup>-1</sup>). In addition, measurements for miscanthus indicate that the annual CO<sub>2</sub> uptake is at least twice that of grassland (Figure 1). Therefore, net soil carbon sequestration may occur on pasture conversion to biomass.

**Considering the short timespan to the 2020 targets and the three- to five-year establishment phase of these crops, urgent policies are required to encourage large-scale adoption of these systems.**

### Mitigation of nitrous oxide

Perennial biomass crops such as miscanthus and willow require less nitrogen (N) fertiliser than pasture or arable systems. In addition, miscanthus and SRC are N-use efficient and are considered to require as little as 50–100 kg N ha<sup>-1</sup>. This represents a large decrease in N application rate when compared to pasture or arable systems and results in lower emissions both of nitrous oxide (N<sub>2</sub>O) and leached N. N<sub>2</sub>O emissions measured on miscanthus and reed canary grass (RCG) plots are less than 300 kg CO<sub>2</sub>-eq ha<sup>-1</sup> yr<sup>-1</sup>, compared with 850–1,400 kg CO<sub>2</sub>-eq ha<sup>-1</sup> yr<sup>-1</sup> for either managed grassland or other biofuel crops such as oilseed rape (OSR) or maize (Figure 2).

In particular, the N<sub>2</sub>O emission factor (the amount of N<sub>2</sub>O-nitrogen emitted per kilogram of N applied) for RCG and miscanthus is >0.4% compared to 1.2–1.4% for other crops (Figure 2). This not only reflects a reduction in N requirement, but also more efficient N uptake by these crops.

There is also an associated saving with the manufacture of N, P and K fertilisers. In terms of other emissions associated with cultivation, including liming, pesticide manufacture, fuel and energy usage, these losses are generally higher than for beef systems but lower than conventional arable systems, due to lower inputs and less annual site maintenance (particularly for miscanthus).

### Displacement of fossil fuel emissions

In terms of fossil fuels replacement, the emissions associated with biomass-derived energy generation are principally associated with cultivation and the release of N<sub>2</sub>O and CH<sub>4</sub> on combustion. By contrast, the emissions associated with gas, oil, coal or peat combustion are primarily due to CO<sub>2</sub> release associated both with mining operations and upon combustion. As a result, total emissions per unit energy produced range from three to seven times higher than that for biomass, depending on the energy content and the carbon content of the fossil fuel being replaced.

Heat production from energy crops is a low cost measure for the Government compared to other options, as no major infrastructure is required. If half of the Government target of supplying 12% of national heat demand by 2020 is met by biomass, the total GHG saving from emissions displacement could equate to over 1.5 million tonnes of CO<sub>2</sub> per year. SRC grown on 109,000 ha would provide enough energy to replace 5% of the oil, gas and electricity used in the residential market and 15% of these fuels used in the commercial market (6.6% of the total heat market). However, mechanisms would need to be put in place to allow agriculture to benefit from the GHG reductions associated with fossil fuel displacement.

### Ireland's energy requirement solution

In conclusion, perennial biomass offers a sustainable solution to Ireland's energy requirement while addressing GHG mitigation within the agricultural sector. However, considering the short timespan to the 2020 targets and the three- to five-year establishment phase of these crops, urgent policies are required to encourage large-scale adoption of these systems.

### References

Duffy, P., Connolly, N. and O'Brien, P. (2011). 'Ireland National Inventory Report 2011'. EPA, Wexford, Ireland.

**Dr Gary Lanigan** is a Research Officer in Johnstown Castle Environment Research Centre. **Dr John Finnan** is a Research Officer in Oak Park Crops Research Centre. **Órlaith Ní Choncubhair** is a Walsh Fellow at UCD and Johnstown Castle investigating the carbon balance of biomass crops. **Dominika Krol** is a Walsh Fellow at Trinity College and Johnstown Castle investigating nitrous oxide emissions associated with biomass crop establishment. E-mail: gary.lanigan@teagasc.ie.



# Every compaction has an equal and opposite reaction

Soil compaction can result in reduced crop yield and surface damage, and can lead to a general deterioration in the functioning of soils. Researchers at Teagasc are instigating a new research programme to protect this vital resource.

Delivery of the Department of Agriculture, Fisheries and Food's *Food Harvest 2020* targets in a post-quota era is likely to increase the demands on soils to deliver grass and crops. Soil is a vital non-renewable resource, which has many functions, including the storage, filtering and transformation of nutrients, substances and water. Soil also acts as a carbon and biodiversity pool and directly supports crop biomass production. One of the main threats to the functionality of soils under Irish conditions is compaction (Creamer *et al.*, 2010). Compaction (deterioration of soil structure) affects agricultural soils throughout the world and, due to Ireland's location in Atlantic Europe with associated high annual rainfall (800-1,400mm), it can be of concern in both grassland and arable systems. The following article documents compaction issues in both arable and grassland systems and brings together existing and new research within Teagasc, which aims to identify actions or mitigation measures that may alleviate soil compaction.

## Old problem – new urgency?

The principal cause of soil compaction in managed arable systems is the force applied to the surface of the soil from field machinery traffic. In arable systems there are increasing and considerable challenges relating to soil structure and compaction, caused by a number of factors such as:

- the increasing weight of farm machinery, with cultivating equipment frequently having axle loads in excess of 7t (harvesters >18t) without an adequate response in tyre size and contact area;
- the increase in continuous tillage production resulting in no recuperative breaks (e.g., two- to five-year grass breaks) leading to a steady decline in soil organic carbon, which in return results in more vulnerable soils with no 'repair' opportunities; and finally,
- Ireland's wet and unpredictable climate, coupled with the need for timeliness with plant establishment and harvesting operations, increases the risk of soil structure damage.

## Depth matters – surface vs. subsoil compaction

Soil compaction can occur within the surface tilled layer, but such cases can be remediated by applying the next tillage operation.

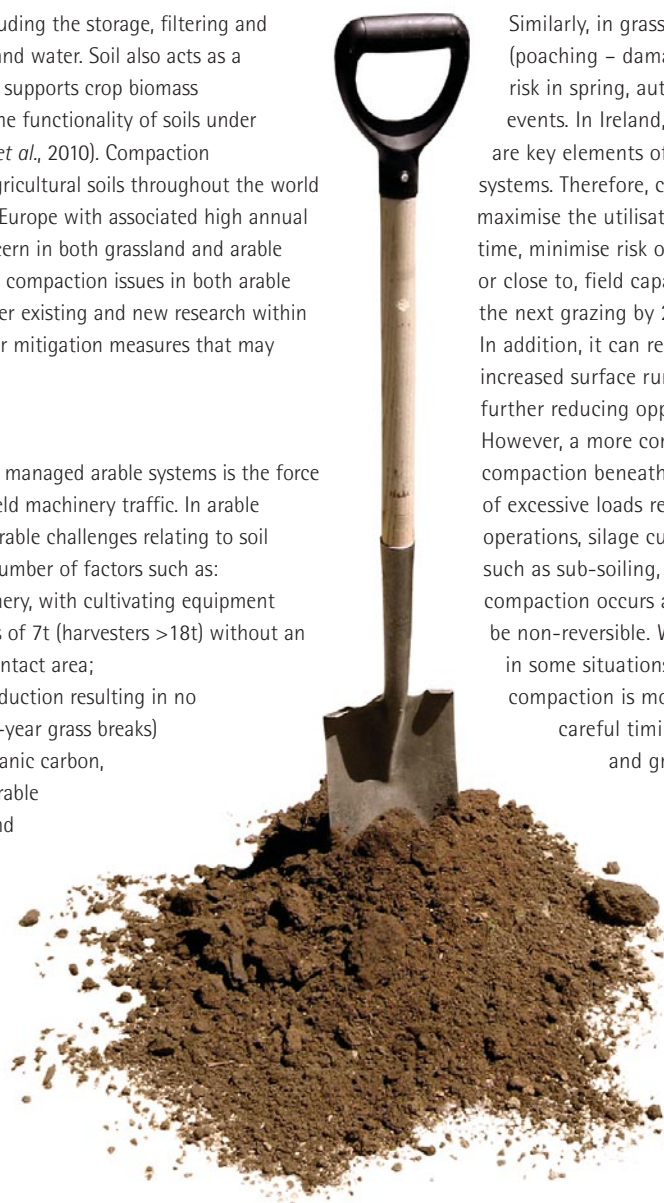
Similarly, in grassland, the potential for damaging the soil surface (poaching – damage caused to sward by the feet of livestock) is a risk in spring, autumn, winter, and during and after heavy rainfall events. In Ireland, short winter housing and early spring turnout are key elements of low cost, grass-based ruminant production systems. Therefore, careful grazing management is required to 1) maximise the utilisation of grass grazed *in situ*; and, 2) at the same time, minimise risk of poaching caused by grazing on soils that are at, or close to, field capacity. Poaching can reduce herbage availability at the next grazing by 20-40% and pasture growth rates by up to 34%. In addition, it can result in reduced soil water infiltration and increased surface runoff, which may result in a negative spiral of further reducing opportunities for grazing.

However, a more complex challenge is presented by deeper subsoil compaction beneath the cultivated layer that may arise from the use of excessive loads relative to tyre sizes/pressures during tillage operations, silage cutting and slurry spreading. Remedial actions here, such as sub-soiling, are expensive and difficult to manage; once compaction occurs at depths of greater than 40cm some effects can be non-reversible. While alleviation of compaction may be necessary in some situations, research indicates that prevention of deep compaction is more cost-effective in such cases, for example by careful timing of machinery operations and by reducing loads and ground pressures.

## Options for remediation

### Grazing management

The effect of dairy cow weight on soil physical properties was investigated on a well-drained soil at Dairygold Research Farm, Moorepark (Herbin *et al.*, 2011). Results showed that soil moisture was the main factor affecting changes in the potential vulnerability to soil compaction.



Dry soil was less sensitive to trampling damage than wet soils. At a soil moisture deficit (SMD) of 0mm, the soil bulk density increased by 6.1% post trampling, whereas it only increased by 3.1%, 4.0% and 0.5% at soil moisture deficits of 11, 14, and 29mm, respectively. Average soil bulk density was 2.3% greater immediately post trampling, and 4.6% greater in the hoof marks. Dairy cow weight significantly increased resistance to soil penetration but had no significant effect on soil bulk density.

New research has just begun on the Teagasc Research Farm in Solohead, Co. Tipperary, where the impacts of cow liveweight (Holstein Friesian – 610kg/cow; Jersey x Holstein Friesian – 480kg/cow) and stocking density on soil physical properties, pasture production and milk output on wet soils is being conducted.

#### Timing of machinery operations

Teagasc research at Teagasc Johnstown Castle, in collaboration with UCD (funded by the Department of Agriculture, Fisheries and Food's Research Stimulus Fund) studies the relationship between SMD and the soil compaction damage incurred following machinery traffic.

The project aims to develop a system for determining the trafficability of soils based on their drainage class and the SMD predictions available through Met Éireann.

#### Mechanical aeration of grassland

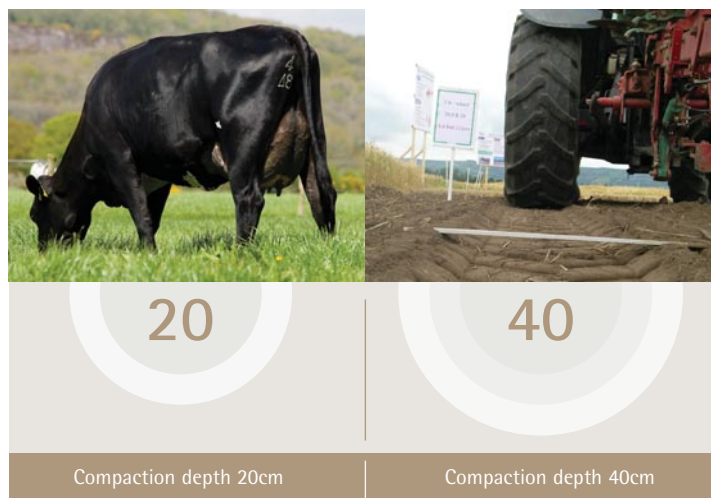
Mechanical aeration (or spiking) of grassland was assessed on previously compacted grassland, and on areas that were subjected to normal grazing and silage practice. The sites ranged from poorly drained to free-draining soils. Over four years, results did not show a consistent benefit from spiking at any site. Spiking can improve soil condition where there is a discrete compact layer near the soil surface. However, this research questions its use in alleviating deeper compaction, or as a general soil treatment.

#### Reduced tyre pressures

Under silage management, research compared the effect of zero, conventional and low ground pressure (LGP) silage harvesting traffic on soil structure and grass yields. The field trials were carried out at Kilmaley, Co. Clare, on a poorly drained soil, and at Oak Park in Carlow on a well-drained soil. The LGP tyres used were considerably larger than anything used in commercial practice, exerting a ground pressure of between 13% and 33% of the conventional traffic at Kilmaley, and between 33% and 50% at Oak Park. The compacting effect on the soil was less where LGP or zero traffic was used, with lower bulk density and higher soil resistance values recorded. Grass yield was also significantly impacted, with LGP traffic giving a 17% increase in annual yield at Kilmaley and a 9% increase at Oak Park.

#### Protecting precious resources

Soil compaction can result in reduced crop yield and surface damage, and can lead to a general deterioration in soil structure. While it is preventable in most cases, damage limitation often requires farmers to make difficult choices involving cost, production and soil protection trade-offs. While existing and currently planned research will help this management process, there will be need for further research in this complex area to allow us to optimise production while protecting our soil resource in our climate.



Compaction in temperate grassland and arable soils.

The projects mentioned are funded by the Teagasc Core Fund and the Department of Agriculture, Fisheries and Food's Research Stimulus Fund.

#### References

- Creamer, R.E., Brennan, F., Fenton, O., Healy, M.G., Lalor, S.T.J., Lanigan, G.J., Regan, J.T. and Griffiths, B.S. (2010). 'Implications of the proposed Soil Framework Directive on agricultural systems in Atlantic Europe – a review'. *Soil Use and Management*, 26: 198-211.
- Herbin, T., Hennessey, D., Richards, K.G., Piowarczyk, A., Murphy, J.J. and Holden, N.M. (2011). 'The effects of dairy cow weight on selected soil physical properties indicative of compaction'. *Soil Use and Management*, 27: 36-44.

Dr Owen Fenton, Dr Dermot Forristal, Dr Rachel Creamer, Dr James Humphreys, Dr Karl Richards, Dr Deirdre Hennessey, Stan Lalor, Patrick Tuohy, and Sara Vero, Teagasc, and Professor Nick Holden, UCD.

E-mail: owen.fenton@teagasc.ie.



# Pesticides from plants

MICHAEL GAFFNEY describes his work on evaluating the potential of phytochemicals within integrated pest management strategies.

Concern with the health and environmental impact of synthetic pesticides has led to increased restrictions and limitations on the use of these products, particularly in the production of food crops. The 'sustainable use of pesticides directive' (Directive 2009/128/EC) places a heavy emphasis on integrated pest management (IPM) as the principal ideology behind the management of crops into the future. Since the 1940s we have come to think of pesticides only as synthetic products of the chemical industry. However, before the 1940s plant extractions containing compounds such as pyrethrum, nicotine and rotenone were routinely used in horticulture. The rediscovery of pesticides based on natural products will be an important tool in developing IPM programmes for field-based horticulture, where classical biological control systems may be less effective due to less favourable climatic conditions. We consider here the control of the black vine weevil using a natural product as part of an IPM strategy.

## The target pest

The larvae of the black vine weevil cause considerable damage in the soft fruit, nursery stock and forestry industries by feeding on the root systems of the plants. This insect generally has one generation per year, usually overwintering as larvae in the soil or growing media. Each adult female can lay approximately 1,300 eggs in the three-month period from July to September each year. All adult weevils are female and reproduce by parthenogenesis, a form of asexual reproduction where eggs develop without fertilisation. There has been considerable progress in developing biological control systems for the larval life stages; however, due to the nocturnal and irregular feeding strategies of the adult vine weevils, and their ability to walk long distances at night (up to 200m), there has been less focus on controlling the adult. The timing of adult vine weevil emergence used to be very predictable; however, as more and more growers are moving under glass and plastic, predicting vine weevil emergence has become less certain. The vine weevil has no diapause period (a period of time where development is slowed or stopped) and its development is largely governed by temperature. This year, larval counts conducted in March and April at commercial nurseries saw higher than usual larval populations, indicating that, despite the good biocontrol options already in use, there is a need to keep developing new control strategies for this insect pest. An obvious gap in vine weevil control strategy is reducing the number of eggs being laid by adults. Adult weevils feed heavily on foliage when they first emerge from the soil for six to eight weeks while their ovaries mature. The notching on leaves is distinctive and is a good indicator of adult emergence and activity. A strategy to target the adult during this period - before they commence egg laying - would be a powerful IPM strategy.



Damage to Azalea plants caused by vine weevil larvae feeding (left), compared to no larval feeding (right).

## Pesticides from plants

The Neem tree (*Azadirachta indica*) is a versatile tree belonging to the family Meliaceae. Extracts and compounds from the neem tree have become increasingly important in IPM strategies due to the increase in pest resistance to synthetic insecticides. Neem extracts have been found to affect more than 200 insect pest species, including beetles and weevils. More than 70 active compounds have been extracted from neem tree material. Azadirachtin is the predominant active ingredient produced by the neem tree. Azadirachtin is a tetranortriterpenoid plant limonoid, with potent insect antifeedant and growth disrupting properties. Azadirachtin is structurally similar to ecdysones, hormones that regulate the moulting process in insects. Crude extracts of neem material usually contain other inactive limonoids such as nimbin and the marginally active compound salannin. Azadirachtin has a low mammalian toxicity and is used extensively in the USA on edible crops. In order to determine the effect feeding neem extracts to vine weevil adults would have, we tested two products, a pure extract containing azadirachtin only and a crude extraction of neem tissue containing azadirachtin and other compounds present in the tissue. We evaluated both products, as insect resistance to crude plant extracts containing many different compounds is less likely than resistance to single compound products.

## Experiment and results

Initially we prepared a number of concentrations of both products, based on azadirachtin content. Foliage was sprayed with these concentrations and fed to adult weevils. Concentrations of 500ppm or more of azadirachtin were found not to be palatable to adult weevils and they would not feed on the treated plant foliage. While this effect could be beneficial by repelling the adults, these concentration levels could be harmful to beneficial insects. We decided to use concentrations of azadirachtin of 200ppm or less in further studies, as these are reported not to be harmful to beneficial insects and from our own investigations are palatable to adult weevils. Adult weevils were reared from larvae and were allowed to develop for four weeks. Groups of 25 adults were then exposed to treated *Euonymus* foliage that was treated with varying concentrations of both products (0-200ppm), once every two weeks for six weeks (three exposures in total). The total number of eggs laid each week was counted, as was the survival and hatching





Brown viable vine weevil eggs and unviable white eggs.

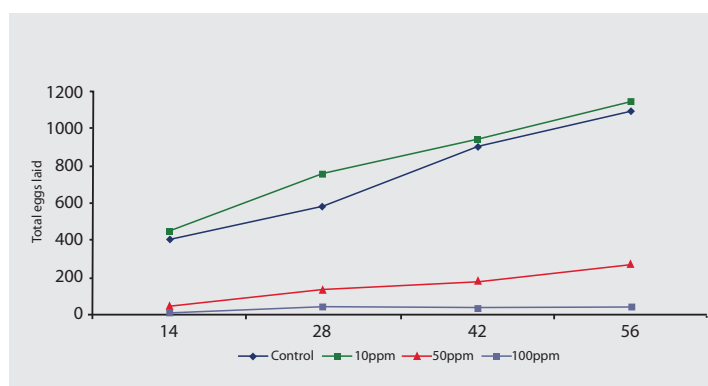
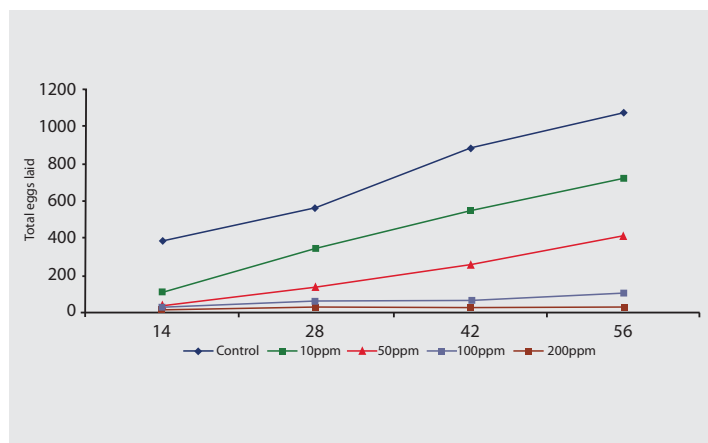
of these eggs. Feeding on foliage treated with either product had a significant effect on egg laying. At the highest rate of azadirachtin (200ppm) there was a 97% reduction in the number of eggs laid using a pure extract of azadirachtin (Figure 1). At a rate of 100ppm of azadirachtin there was a 90% reduction in the number of eggs laid using a pure extract, and a 97% reduction in eggs laid using a crude extract (Figures 1 and 2). Using odds ratio analysis, we estimate (95% confidence limits) that for every 1,000 eggs laid by a population of weevils, that same weevil population, when fed azadirachtin-treated foliage at 100ppm, would only lay 138 eggs (pure extract) and 13 eggs (crude extract).

Feeding azadirachtin-treated foliage to adults also had an effect on the viability of eggs that were laid. Egg hatching is preceded by a colour change from white to brown; white eggs will not hatch (see photo above). Hatch rate fell from 70% in the control treatment to less than 30% at the higher treatment rates (Figure 3). This indicates that treatments caused physiological disruption of the reproductive cycle and direct damage to the ovaries of the insects.

### Benefit to the industry

There are no azadirachtin-containing plant protection products currently registered for use in Ireland. However, as of June 2011, azadirachtin was included within Annex I of Directive 91/414/EEC and several member states are in the process of seeking registration of azadirachtin-containing products. The first likely registration for an azadirachtin plant protection product will be for use against Colorado potato beetle in Germany. Unlike current biological control strategies for the larval stage, such as entomopathogenic nematodes and fungi, neem extracts such as azadirachtin are not affected by low ambient temperatures; indeed, azadirachtin is more stable at low temperatures. Grower feedback and personal observation would estimate current control levels of 50 to 80% being achieved for this insect. Incorporating foliar sprays containing azadirachtin could potentially increase weevil control while having little negative impact on the environment and beneficial insects.

*This research was funded by Teagasc core funding under the Walsh Fellowship Scheme. The author would like to acknowledge the assistance of Dr Jim Grant, Statistical Support Unit, Teagasc.*



FIGURES 1 and 2: Total number of eggs laid by vine weevils fed *Euonymus* foliage treated with a pure formulation (Figure 1, top) and crude extract (Figure 2) of azadirachtin over 56 days.

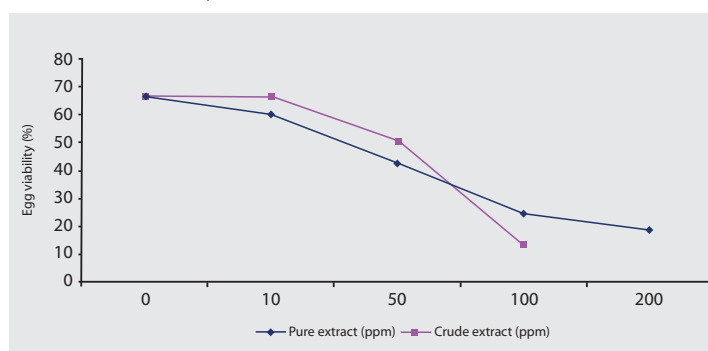


FIGURE 3: Decreasing egg viability due to increasing azadirachtin concentration on treated foliage.

**Michael Gaffney** is a Researcher and Protected Crops Specialist in the Horticulture Development Department, Kinsealy.  
E-mail: michael.gaffney@teagasc.ie.



# Antibiotic resistance in *Campylobacter*

DECLAN BOLTON and SÉAMUS FANNING outline the molecular basis for antibiotic resistance in *Campylobacter* spp.

**C***ampylobacter* infection is the most common cause of acute bacterial gastroenteritis in developed countries (Randall *et al.*, 2003). After an average incubation period of three days, most cases present with abdominal pain and diarrhoea, and the infection is self-limiting. However, in approximately one-third of cases a period of fever and malaise accompanied by rigors, general aches, dizziness and delirium occurs for approximately 24 hours before the onset of gastrointestinal symptoms. Patients presenting with the latter tend to suffer more severe disease and require therapeutic intervention – usually a course of treatment with fluoroquinolone or macrolide antibiotics (O'Brien, 2002).

## Emerging quinolone resistance

In the last decade, antibiotic resistance in *Campylobacter* has emerged and spread rapidly. Many studies have attributed this resistance to the use of antimicrobial agents in poultry production (Humphrey *et al.*, 2005). Control of the emergence and dissemination of antimicrobial resistance in *Campylobacter* requires a fundamental understanding of the molecular basis of the observed phenotypes, and several mechanisms for antibiotic resistance in *Campylobacter* have been identified, including modification (mutation) of target genes and activation of efflux pump systems. Fluoroquinolones, such as enrofloxacin, target the DNA gyrase enzyme in Gram-negative bacteria. Resistance to this class of drug may develop when a mutation in the *gyrA*-encoding subunit of the DNA gyrase gives rise to one or more amino acid substitutions (Griggs *et al.*, 2005) within the DNA-binding domain in a region termed the quinolone resistance-determining region (QRDR). For example, the Thr-86-Ile amino acid substitution in the QRDR is sufficient to confer a resistant phenotype in *Campylobacter jejuni* and *Campylobacter coli* (Piddock *et al.*, 2003; Luo *et al.*, 2003). Other modifications of the *gyrA* subunit have also been associated with quinolone resistance, including Asn-203-Ser (Piddock *et al.*, 2003).

## Mechanisms of macrolide resistance

Macrolides, such as erythromycin, inhibit protein synthesis in *Campylobacter* by binding to their ribosomes, causing dissociation of the peptidyl-tRNA and thereby



preventing bacterial growth. Resistance is mediated through two mechanisms: modification of the antibiotic target by mutation; and, expulsion of the drug from the bacterial cell by efflux (Taylor *et al.*, 2005).

The former is the most common mechanism. It may arise following point mutations at positions 2074 and/or 2075 in the 23S rRNA of the large (50S) ribosomal subunit or by mutations in the ribosomal proteins L4 and L22 (Taylor *et al.*, 2005; Corcoran *et al.*, 2006).

Other factors may also contribute to the resistance phenotype. Efflux of drug(s) confers a multi-drug resistance (MDR) phenotype to *Campylobacter*. The CmeABC efflux pump, for example, is known to promote both intrinsic and acquired resistance (Payot *et al.*, 2004; Ge *et al.*, 2005) to a range of antimicrobial agents, including fluoroquinolones and macrolides in *Campylobacter* species.

## Resistance research at Teagasc

Research was recently undertaken at Teagasc Food Research Centre, Ashtown, to investigate the role of both target gene mutations and efflux pump activity in fluoroquinolone and macrolide resistance in *Campylobacter* isolates from intensively reared Irish poultry. Microdilution and E-test methods were initially applied to determine the minimum inhibitory concentrations (MIC) for two quinolone-based drugs (nalidixic acid and ciprofloxacin) and one macrolide (erythromycin). Using PCR and gene-sequencing technologies, the role of target gene mutations in resistant isolates was investigated, while the role of efflux was examined using phenylalanine arginine  $\beta$ -naphthylamide (PABN) – a known efflux pump inhibitor. High-level resistance to nalidixic acid was attributed to amino acid substitutions Thr-86-Ile and Asn-203-Ser in *gyrA* of the DNA gyrase enzyme in some, but not all, isolates and, contrary to previous reports, the Thr-86-Ile substitution did not confer universal resistance to all quinolones. As expected, the 23S rRNA point mutation A2075G and/or amino acid substitutions in the L4 and/or L22 ribosomal proteins were identified in erythromycin-resistant strains. However, in contrast to previous studies, not all of the isolates carrying substitutions within the  $\beta$ -hairpin region of the L22 ribosomal protein exhibited erythromycin resistance. In general, efflux did not contribute to either quinolone or macrolide resistance.



Far left: This scanning electron microscope image shows the characteristic spiral, or corkscrew, shape of *C. jejuni* cells and related structures. Image courtesy of Agricultural Research Service, United States Department of Agriculture. Photo by De Wood; digital colourisation by Chris Pooley.

Left: Many studies have attributed antibiotic resistance in *Campylobacter* to the use of antimicrobial agents in poultry production.

### Relevance to industry

Our research therefore supports the hypothesis that quinolone and macrolide antibiotic resistance in *Campylobacter* is mutation based. While this trait may not be transferred horizontally from one organism to another, it is relatively stable in the *Campylobacter* population and can be passed vertically between parents and offspring cells. The use of antibiotics during food production will confer a selective pressure, promoting the survival and proliferation of resistant strains, while susceptible organisms are eliminated from the microflora with inevitable adverse consequences for therapeutic intervention (in severe cases) and public health.

### Acknowledgement

This work was funded by safefood, the Food Safety Promotion Board.

### References

- Corcoran, D., Quinn, T., Cotter, L. and Fanning, S. (2006). 'An investigation of the molecular mechanisms contributing to high-level erythromycin resistance in *Campylobacter*.' *International Journal of Antimicrobial Agents*, **27**: 40-45.
- Ge, B., McDermott, P.F., White, D.G. and Meng, J. (2005). 'Role of efflux pumps and topoisomerase mutations in fluoroquinolone resistance in *Campylobacter jejuni* and *Campylobacter coli*.' *Antimicrobial Agents and Chemotherapy*, **49**: 3347-3354.
- Griggs, D.J., Johnson, M.M., Frost, J.A., Humphrey, T., Jørgensen, F. and Piddock, L.J. (2005). 'Incidence and mechanism of ciprofloxacin resistance in *Campylobacter* spp. isolated from commercial poultry flocks in the United Kingdom before, during, and after fluoroquinolone treatment.' *Antimicrobial Agents and Chemotherapy*, **49**: 699-707.
- Humphrey, T.J., Jørgensen, F., Frost, J.A., *et al.* (2005). 'Prevalence and subtypes of ciprofloxacin-resistant *Campylobacter* spp. in commercial poultry flocks before, during, and after treatment with fluoroquinolones.' *Antimicrobial Agents and Chemotherapy*, **49**: 690-698.
- Luo, N., Sahin, O., Lin, J., Michel, L.O. and Zhang, Q. (2003). 'In vivo selection of *Campylobacter* isolates with high levels of fluoroquinolone resistance associated

with *gyrA* mutations and the function of the CmeABC efflux pump.' *Antimicrobial Agents and Chemotherapy*, **47**: 390-394.

O'Brien S.J. *The Campylobacter Sentinel Surveillance Scheme.* (2000).

'Ciprofloxacin resistance in *Campylobacter jejuni*: case-case analysis as a tool for elucidating risks at home and abroad.' *Journal of Antimicrobial Chemotherapy*, **50**: 561-568.

Payot, S., Avrain, L., Magras, C., Praud, K., Cloeckert, A. and Chaslus-Dancla, E. (2004). 'Relative contribution of target gene mutation and efflux to fluoroquinolone and erythromycin resistance, in French poultry and pig isolates of *Campylobacter coli*.' *International Journal of Antimicrobial Agents*, **23**: 468-472.

Piddock, L.J., Ricci, V., Pumbwe, L., Everett, M.J. and Griggs, D.J. (2003). 'Fluoroquinolone resistance in *Campylobacter* species from man and animals: detection of mutations in topoisomerase genes.' *Journal of Antimicrobial Chemotherapy*, **5**: 19-26.

Randall, L.P., Riddly, A.M., Cooles, S.W., *et al.* (2003). 'Prevalence of multiple antibiotic resistance in 443 *Campylobacter* spp. isolated from humans and animals.' *Journal of Antimicrobial Chemotherapy*, **52**: 507-510.

Taylor, D.E. and Tracz, D.M. (2005). 'Mechanisms of antimicrobial resistance in *Campylobacter*.' In: Ketley, J.M. and Konkel, M.E. (Eds.). '*Campylobacter*: molecular and cellular biology.' *Horizon Bioscience*, Norfolk; pp. 193-204.

---

Dr Declan Bolton, Food Safety Department, Teagasc Food Research Centre, Ashtown, Dublin 15. Professor Séamus Fanning, UCD Centre for Food Safety, School of Public Health, Physiotherapy & Population Science, UCD Veterinary Sciences Centre, University College Dublin, Belfield, Dublin 4.  
E-mail: declan.bolton@teagasc.ie.



## Seaweed – does the heart good

Researchers at Teagasc have been investigating lipids from a variety of Irish and Canadian seaweed species for their heart-health properties.

*The value added sector of the seaweed industry in Ireland has emerged to produce attractive, high-quality products for use as functional body care products and cosmetics. Scientists at Teagasc are now looking into seaweed as a source of bioactive compounds for functional food ingredients. Pictured is the common Irish species spiral or flat wrack (Fucus spiralis).*



Image courtesy of Dr. Anna Soler, NUIG.

In both Ireland and Canada (provinces of Newfoundland and Labrador), seaweeds have a long tradition of use. In Ireland, for example, approximately 36,000 tonnes of seaweed are harvested annually (NutraMara Feasibility Study, 2011). Seaweed species of commercial interest in Ireland include *Laminaria digitata* and *Fucus* species (*Fucus vesiculosus*, *Fucus serratus* and *Fucus spiralis*), which are harvested primarily for their valuable carbohydrates, laminarin and fucoidan, respectively. The value-added sector of the seaweed industry in Ireland has emerged to produce attractive, high-quality products for use as functional body care products and cosmetics.

### Seaweed as functional food ingredient

However, there is, to date, limited activity aimed at exploiting Irish seaweed resources as materials for functional food ingredients with enhanced health benefits that go beyond basic nutrition for the consumer. The NutraMara Research Programme is currently working at developing the area of marine-origin functional foods in Ireland. In April 2010, Michelle Tierney – a Teagasc Walsh Fellow core-funded PhD student who works on the isolation and characterisation of bioactive polyphenols and peptides from Irish seaweed species as part of the NutraMara project – and her supervisor, Dr Maria Hayes, the current NutraMara Scientific Project Manager, travelled to Memorial University, Newfoundland, Canada, as part of a successful application for funding from the Third Level Ireland–Newfoundland Marine Research Grant Scheme. They visited the laboratories of Professor Fereidoon Shahidi as part of a collaborative project to isolate marine antioxidant and ACE-I inhibitory peptides and polyphenols (specifically phlorotannins) from sustainable seaweeds from Ireland and Newfoundland, including *Ascophyllum nodosum*, *Ulva intestinalis*, *F. spiralis* and *Pelvetia canaliculata* (Irish seaweeds) and *Fucus distichus*, *Alaria esculenta* and *Palmaria palmate* (Newfoundland species).

### Regulation of blood pressure – peptides and polyphenols

High blood pressure is one of the most common cardiovascular diseases, affecting between 10 and 20% of the adult population. It is responsible for

approximately 5.8% of all deaths worldwide and a 5mmHg reduction in diastolic blood pressure reduces the risk of cardiovascular disease by approximately 16% in hypertensive subjects (Fitzgerald *et al.*, 2004). Angiotensin-I-converting enzyme (ACE, EC 3.4.15.1) is a zinc-containing metalloenzyme that is known to perform an important physiological function in the pathogenesis of cardiovascular disease and in the regulation of blood pressure in the renin-angiotensin system (RAS) (Jung *et al.*, 2006). ACE-I-inhibitory peptides have been isolated from the hydrolysates of seaweeds previously and the ACE-I inhibitory activities of phlorotannins from *Ecklonia stolonifera* are also known (Jung *et al.*, 2006). Furthermore, seaweeds, or macroalgae, as photosynthetic organisms, are exposed to a combination of light and high oxygen concentrations that induce the formation of free radicals and other oxidative reagents, which are extremely damaging to cells. The absence of structural damage in the algae means that these organisms can generate antioxidants and necessary compounds to protect themselves against this oxidation. Therefore, they are considered important sources of antioxidants (Plaza and Ibanez, 2008). Polyphenols are antioxidants. Others include phlorotannins, phycobiliproteins and vitamins (vitamin C), which are found in the water-soluble fractions, whereas vitamin E and carotenoids are found in the fat-soluble fractions of seaweeds (Plaza and Ibanez, 2008). The protective effect of dietary polyphenols against vascular risk, i.e., their ability to decrease the ischaemic obstruction events rate, might be attributed, in part, to their ability to retard the progression of early atherosclerotic lesions to advanced plaques, which are prone to rupture with superimposed thrombosis (Stoclet *et al.*, 2004).

### Seaweed essential fatty acids

In addition to peptides and polyphenols, seaweed lipids were reported previously to show high bioactive functionalities. Algae contain many of the major lipids of plants, such as the glycosylglycerides and phosphoglycerides. In addition, more unusual compounds, such as the betaine lipids, chlorosulfolipids or various other sulfolipids may be major components of some seaweed species or orders. Seaweeds are also a known source of essential fatty acids, which are

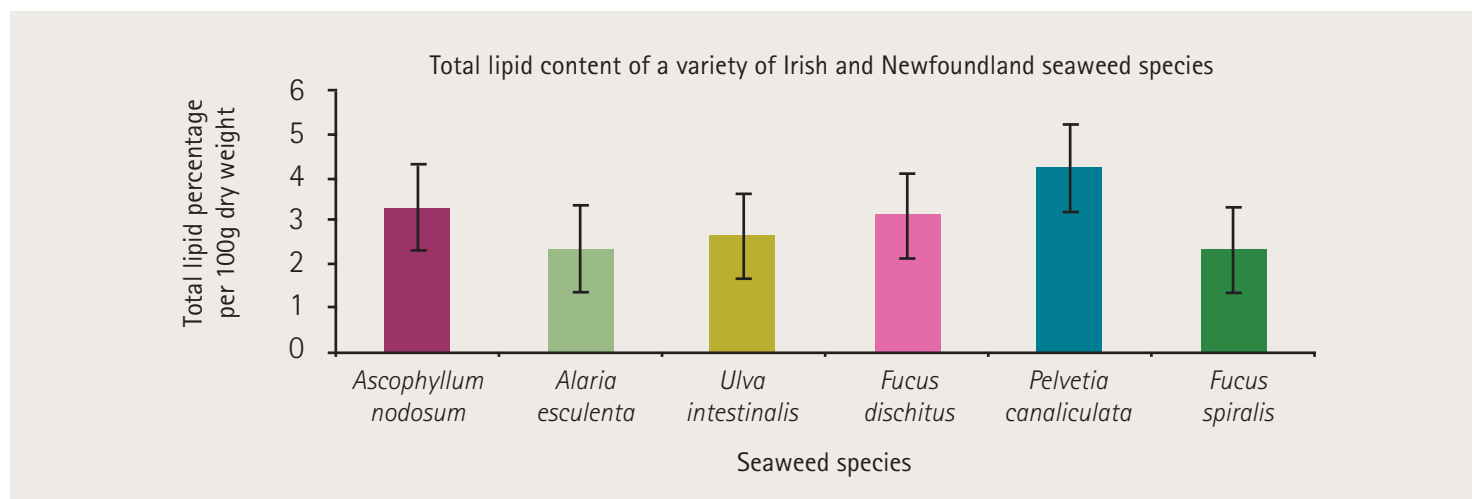


FIGURE 1: Total lipid content of a variety of Irish and Newfoundland seaweed species.

thought to reduce thrombosis and atherosclerosis – factors important in the reduction of the risk of heart disease. Seaweed lipids contain high levels of omega-3 polyunsaturated fatty acids (PUFAs) such as 18:4n-3 (stearidonic acid; SDA), and 20:5n-3 (eicosapentaenoic acid; EPA), together with the omega-6 PUFA, 20:4n-6 (arachidonic acid; AA). The lipid fraction of seaweeds, although present in the seaweed in relatively small quantities compared to the other major nutrients, proteins and carbohydrates, also contains fucoxanthin, polyphenols and fucosterol bioactive components.

### Teagasc research

As part of their work in Newfoundland, Michelle Tierney and Dr Maria Hayes developed methods for the isolation of total lipids from a number of seaweed species. Of the eight Irish and Newfoundland seaweed species used in this study, the Irish seaweed, *P. canaliculata*, kindly supplied by Dr Anna Soler of the Irish Seaweed Centre, Galway (ISCG), had the highest percentage of total lipids per dry weight (Figure 1), followed by the sustainable Irish seaweed *A. nodosum*, also supplied by the ISCG. All seaweeds yielded a total lipid content of  $\leq 4\%$ , in keeping with previous reports (Sanchez-Machado *et al.*, 2004). Further work is currently underway at the Teagasc Food Research Centre, Ashtown, concerning the bioactivity profiles and bioactive component isolation of all seaweed lipid extracts. During the course of this visit, links were also formed between Teagasc Food Research Centre, Ashtown, and the Centre de Recherche sur les Biotechnologies Marines and the Institute for NutriSciences and Health, Canada. These lipids could potentially be used in food vehicles such as bread and soup type products in the future.

### Acknowledgements

We gratefully acknowledge the assistance of Professor Fereidoon Shahidi, Memorial University, St. John's Newfoundland, and Dr Anne Mathieu, Oceans Ltd, St. John's Newfoundland, for supply of the Newfoundland seaweed species used in this study, and Dr Anna Soler, the Irish Seaweed Centre, Galway, for supply of the Irish seaweed species as part of the NutraMara project.

NutraMara is funded by the Department of Agriculture, Fisheries and Food (DAFF) and the Marine Institute (MI). We also gratefully acknowledge Roinn an Taoisigh and the Ireland–Newfoundland Marine Research Grant Scheme for financial support for this project.

### References

- FitzGerald, R., Murray, B.A. and Walsh, D.J. (2004). 'Hypotensive peptides from milk proteins'. *The Journal of Nutrition (Supplement)*, **134**: 980S–988S.
- Jung, H.A., Hyun, S.K., Kim, H.P. (2006). 'Angiotensin-converting enzyme I inhibitory activity of phlorotannins from *Ecklonia stolonifera*'. *Fisheries Sciences*: 1292–1299.
- Plaza, A., Ibanez, E. (2008). 'In search of new functional food ingredients from algae'. *Trends in Food Science and Technology*, **19**: 31–39.
- Sanchez-Machado, D.I., Lopez-Cervantes, J., Lopez-Hernandez, J., Paseiro-Losada, P. (2004). 'Fatty acids, total lipid, protein and ash contents of processed edible seaweeds'. *Food Chemistry*, **85**: 439–444.
- Stoclet, J.-C., Chataigneau, T., Ndiaye, M., Oak, M.-H., El Bedoui, J., Chataigneau, M. and Schini-Kerth, V.B. (2004). 'Vascular protection by dietary polyphenols'. *European Journal of Pharmacology*, **500 (1–3)**: 299–313.
- Tierney, M.S., Croft, A.K., Hayes, M. (2010). 'A review of antihypertensive and antioxidant activities in macroalgae'. *Botanica Marina*, **53**: 387–403.

Dr Maria Hayes is a Research Officer and Michelle Tierney is a Teagasc Walsh Fellow in the Food BioSciences Department, Teagasc Food Research Centre, Nutraceutical Research Facility, Ashtown, Dublin 15. E-mail: maria.hayes@teagasc.ie.



# Thermal analysis of foods

New approaches to the thermal analysis of foods at Teagasc Food Research Centre, Moorepark, are described by SONG MIAO and MARK FENELON.

Foods are complex systems, which are subjected to variations in temperature during manufacture (sterilisation, cooking, freezing and chilling), transport, storage and final preparation. Thermal treatment can alter the physical and chemical properties of food components, influencing the overall quality of the final product, e.g., sensory and stability attributes. Chemical reactions such as Maillard reaction, enzymatic hydrolysis, oxidation or reduction can be promoted, and/or physical changes, such as evaporation, melting, crystallisation, aggregation or gelation may occur.

Understanding the influence of temperature on physicochemical/structural changes in food provides manufacturers with a mechanism for optimisation of processing conditions and, ultimately, improves product quality. Therefore, analytical techniques for monitoring thermally-induced changes in food are important for food research and development personnel.

## What is thermal analysis?

Thermal analysis (TA) is the term used to describe the analytical techniques that measure the physical and chemical properties of a sample as a function of temperature or time. In principle, most analytical techniques can be used, or easily adapted, to monitor the temperature-dependent properties of foods, e.g., spectroscopy (NMR, UV-visible, IR spectroscopy, fluorescence), scattering (light, x-rays, neutrons), physical (rheology, TA), etc. However, the term 'thermal analysis' is usually reserved for a narrow range of techniques that measure changes in the physical properties of foods with temperature, e.g., mass, density, rheology and heat capacity.

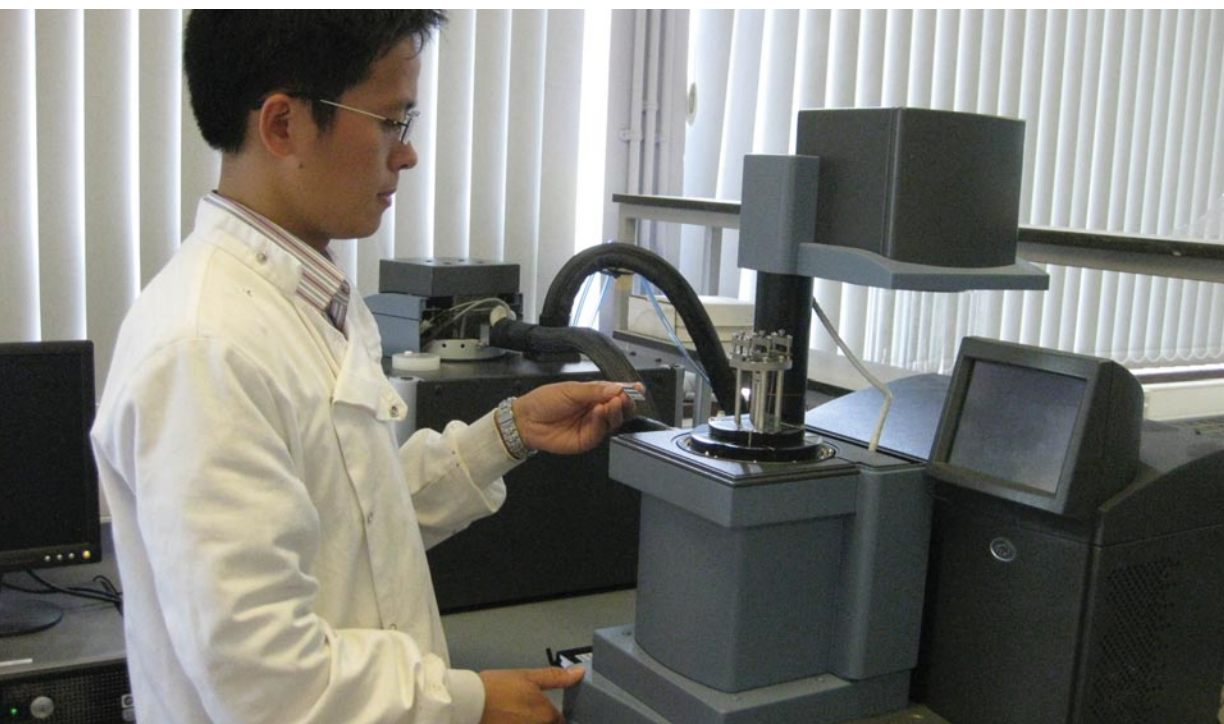
In this area, the most common techniques used, which have been shown to yield meaningful results for the evaluation of foods and their raw ingredients, are: 1) differential scanning calorimetry (DSC); 2) dynamic mechanical analysis (DMA); and, 3) thermogravimetry (TG).



Image courtesy of Bord Bia.

## Teagasc investment

Teagasc, with the support of the Teagasc Vision Programme, recently installed state-of-the-art DSC (Q2000 Tzero DSC, TA Instruments) and DMA (Q800, TA Instruments) instrumentation in the Food Chemistry and Technology Department at Teagasc Food Research Centre, located at Moorepark. Methodologies have been developed and the instruments are validated for a comprehensive range of TA applications, enhancing the capability of food materials science within the Department. DSC is a technique for recording the energy required to keep a zero temperature difference between a sample cell and a reference cell, which are either heated or cooled at a controlled rate. During a phase transition in a food system, heat is either absorbed or released, measured as an enthalpy or energy change. This change in enthalpy can be related to structural changes, e.g., crystallisation, denaturation and/or aggregation. DSC data is therefore reported as the rate of energy absorption (Q) by the sample relative to the reference material as a function of the external temperature. It should be noted that it is also possible to measure the change in the heat released by a material as a function of time under isothermal (constant temperature) conditions for information on reaction kinetics. With an auxiliary liquid nitrogen cooling system (LNCS) attached, linear heating rates of up to 200°C/min can be reached. DMA is a technique used to measure the mechanical properties of viscoelastic materials, such as modulus (stiffness) and damping (energy dissipation), as a function of temperature or frequency when the materials are deformed under the action of a periodic force or displacement. DMA provides quantitative and qualitative information on Young's modulus and shear modulus values, damping characteristic/viscoelastic behaviour, polymer structure and morphology, flow, and stress relaxation behaviour of polymeric materials. The Q800 DMA provides all the major deformation modes required to characterise solid bars, elastomers, soft foams, thin films and fibres. In addition, film tension clamps and powder/liquid sample holders are also available. An auxiliary relative humidity unit allows the mechanical properties of samples to be analysed under constant and/or varying conditions of both humidity and temperature.



*Far left: Moorepark's focus is on characterisation of food ingredients and products such as protein bars, infant formula and dairy ingredients.*

*Left: Walsh Fellow, Like Mao, using DMA for measuring the mechanical properties of dairy ingredient powders.*

### Applications in food research

DSC is the most widely used TA technique in food research and is a valuable tool in the quality assurance of foods. The most common food components studied by TA are proteins. These analyses include studies on conformation changes as affected by various environmental factors: thermal denaturation of tissue proteins; food enzymes and enzyme preparations for the food industry; and, the effects of various additives on the thermal properties of proteins. Freezing-induced denaturation of food proteins and the effect of cryoprotectants, such as sugars, can also be monitored. DSC can also be used to characterise different types of physical behaviours, for example, to study the gelatinisation behaviour of starches and the interaction of starch with other food components such as proteins. The technique can be used to study phase/state transitions during drying/baking. Studies on crystallisation and melting behaviour of fats observed by DSC can indicate changes in lipid composition and/or be used for differentiation of individual products. Thermal oxidative decomposition of edible oils examined by DSC can be used for predicting oil stability. Using DSC in the freezing range has a great potential for measuring and modelling frozen food thermal properties, and to estimate the state of water in foods and food ingredients. Research in food microbiology utilises DSC in better understanding thermoadaptive mechanisms or heat inactivation of food-borne microorganisms. DMA, as the most sensitive thermal analytical technique, has been used to measure the changes in structural and intrinsic properties of polymeric materials. While application in food research is still quite new, DMA has been used to study starch gelatinisation, mechanical relaxation of food ingredients, mechanical properties of edible films and viscoelastic properties of food products. The DMA storage and loss moduli obtained provide valuable information about the softness and keeping properties of bread, as well as the cooking characteristics of pasta. Current studies at Moorepark are focused on characterisation of food ingredients/products to understand the mechanical behaviour/properties such as

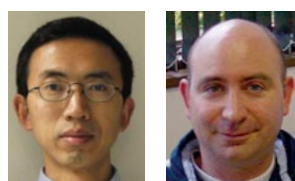
stickiness and relaxation, which influence the texture and physicochemical stability of foods such as protein bars, infant formula, and dairy ingredients.

### Benefit to industry

The new TA equipment strengthens the research and development capabilities of the Irish food industry. This equipment enables the measurement of the actual physical properties of food materials and products, and the determination of their thermal and mechanical histories. Hence, TA will assist in the optimisation of processes used in food manufacture and the stability of foods in various environments. An example of the latter, which is of practical relevance in food formulation, is the influence of proteins on the gelatinisation of starch and its impact on the physicochemical stability and textural properties of products such as dairy desserts.

*This facility is funded by the Teagasc Vision Programme.*

**Dr Song Miao**, Senior Research Officer, Department of Food Chemistry and Technology, Teagasc Food Research Centre, Moorepark. **Dr Mark Fenelon**, Principal Research Officer, Teagasc Food Research Centre, Moorepark. For further information and to arrange access to the equipment, E-mail: [song.miao@teagasc.ie](mailto:song.miao@teagasc.ie).



# Epigenetics – linking nurture to nature



Recent advances have shown how the environment can affect gene function. KIERAN MEADE explains the relevance of epigenetics and Teagasc's new initiatives in this area.

Conventional evolutionary theory holds that genetic information flows in only one direction – from DNA to RNA to proteins, which are the workhorses and building blocks of our body. However, evidence now shows that the environment can imprint information onto genes by chemically modifying their DNA or histones, the proteins around which DNA is wound. These modifications can thereby affect the function of the gene, and any trait with which they are associated.

Epigenetics is the term given to the study of how these chemical modifications of DNA affect gene function and, more controversially, how these modifications can be inherited. So epigenetics is now blowing open the nature versus nurture debate and linking the environment and genetics. Evidence from studies in several species suggests that the 'epi' genome may be as important as genetic variation in the determination of phenotype. Therefore, understanding how epigenetics regulates the function of genes will be key to efficiently capturing traits of interest in animals and plants, and will have profound implications for agriculture.

## Epigenetic regulation of gene expression

The two main mechanisms of epigenetic control are histone modification and DNA methylation (Figure 1). DNA methylation is the addition of a methyl group to specific bases of DNA, which most often occur in mammals at cytosine (C) nucleotides, which are located beside a guanine (G) nucleotide. This modification results in the C molecule being converted to 5-methylcytosine, now commonly referred to as the fifth base of DNA. Regions of the genome that contain areas of very high-density C and G residues are known as CpG islands. Importantly, about 40% of mammalian gene promoters (and 70% of human promoters) contain CpG islands and so have the potential to be methylated.

Generally speaking, DNA methylation is an inhibitory mechanism, often acting to repress gene transcription. Acetylation, however, generally facilitates gene transcription. The addition of a negatively charged acetyl group to a histone neutralises the positive charge on the histone. As a result, the condensed DNA is relaxed, allowing greater levels of gene transcription. These epigenetic modifications and their ability to alter gene expression levels, may have downstream effects for the trait that the gene influences (e.g., muscle growth, milk yield or the immune response) and, therefore, the phenotype of the animal. Interestingly, some of these modifications have been shown to be heritable, meaning that if epigenetic modifications occur during a lifetime as a result of environmental effects, these modifications can be passed on to offspring and possibly even to further generations.

## Epigenetic effects on growth, lactation and behaviour

The potential for epigenetic regulation of important genes in cattle means that for the research we carry out in Teagasc, the epigenome of the animal needs to be understood in order to efficiently capture the trait of interest in selected livestock. An impressive body of evidence now exists to show that epigenetics and nutrition are inherently linked in humans. One famous study examines the effect of a 19th century famine in northern Sweden. The offspring of children who grew up during non-famine times were healthier and physically bigger than the offspring of individuals who grew up during years of food shortage. This finding correlated with epigenetic changes in the IGF2 gene (Kaati *et al.*, 2007), a gene that, interestingly, has been associated with oocyte competence, milk yield and other production traits in cattle. It has been postulated that energy restriction can also induce epigenetic changes that alter mammogenesis and subsequent lactation performance. An inverse relationship between the level of methylated DNA and the expression of milk protein genes in the mammary gland has also been suggested. These findings may have important implications for mammary function in both beef and high-yielding dairy cows. Another complex trait of agricultural interest is behaviour. Research in mice has shown that diet and, separately, mothering ability can influence the feeding behaviour and stress levels of offspring (Weaver *et al.*, 2004; Waterland *et al.*, 2006). Increased nursing and grooming gave rise to less stressed offspring, which could be measured via differential methylation patterns of the glucocorticoid receptor gene in the hippocampus. Importantly, these effects were found to be reversible through the inhibition of gene methylation. This fascinating research would have important implications for calf rearing and potentially identifying mechanisms for the manipulation of animal behaviour. It is likely that for complex traits, such as growth or health, epigenetics will have an even greater role to play.

Genetics + Epigenetics = Phenotype

## The emerging field of patho-epigenetics

'Patho-epigenetics' links aberrant DNA methylation with the development of infectious disease. Again, in studies of human pathogens, the bacteria *Helicobacter pylori*, which causes gastric inflammation, has been shown to induce methylation at various gene promoters including that of E-cadherin (Niwa *et al.*, 2010). The potential of a pathogen to manipulate the immune response of the host via methylation – in order to facilitate its survival – also means that emerging epigenetic drugs may have significant promise for the treatment and eradication of diseases. Some DNA



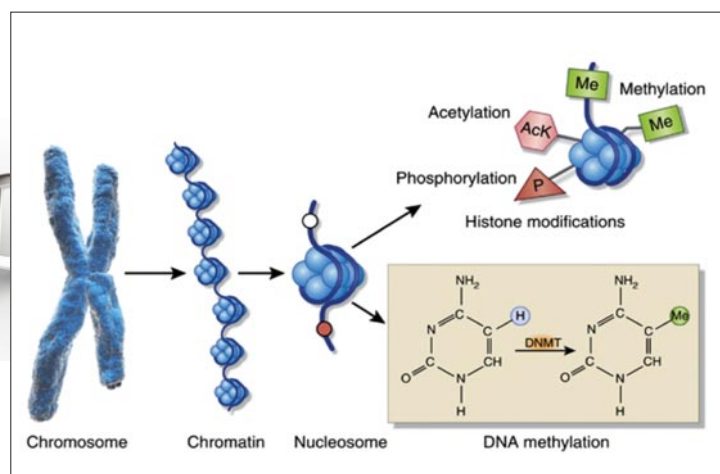


FIGURE 1: The two major classes of epigenetic modification – histone modification and DNA methylation. Adapted from 'Beyond genetics: epigenetic code in chronic kidney disease' (Raj *et al.*, 2011).

demethylating agents are already approved for the treatment of some human cancers. During mastitis in cows, an infection caused by *Escherichia coli*, the alpha S1-casein encoding gene was shown to have increased levels of methylation, which may facilitate the survival of the bacteria in the mammary gland by dampening down the immune response. This evidence suggests that other infections that commonly affect cattle could cause similar effects and that the DNA methylation patterns in both virally and bacterially infected animals warrant detailed investigation. The methylation status of an animal's DNA could help to determine their disease susceptibility.

### Epigenetics research in Teagasc

Teagasc is supporting some of the first epigenetic studies in cattle in Ireland. The aim of the current project is to identify DNA methylation changes in tuberculosis-infected animals and to understand the interplay between methylation and immunosuppression. We have previously found that infected animals exhibit suppression in the expression of immune genes, which could be contributing to unresolved infection. If methylation of key immune genes is contributing to immunosuppression, releasing the epigenetic tags may allow an animal to better fight infection. Furthermore, epigenetic profiles or markers could provide informative diagnostics for disease, including for sub-clinical infection. Interestingly, a signature pattern of increased levels of methylated DNA found in plasma has been shown in relation to certain cancers and inflammatory diseases in humans. There could be diagnostic potential here if similar signatures can be found in relation to tuberculosis infection in cattle.

With collaborative expertise, facilities and samples from resource animals available through our research partners (Trinity College Dublin, University College Dublin, and the Department of Agriculture, Food and the Marine), Teagasc is well positioned to illuminate the role of epigenetic regulation of the immune response in cattle and in determining an animal's susceptibility to infection. Although the focus of the current work is on health, DNA methylation changes may also have significant relevance in aspects of animal production and behaviour traits. It has become clear that epigenetics and epigenomics – the genomewide distribution of epigenetic changes – will be essential to an accurate understanding of the complete set of factors

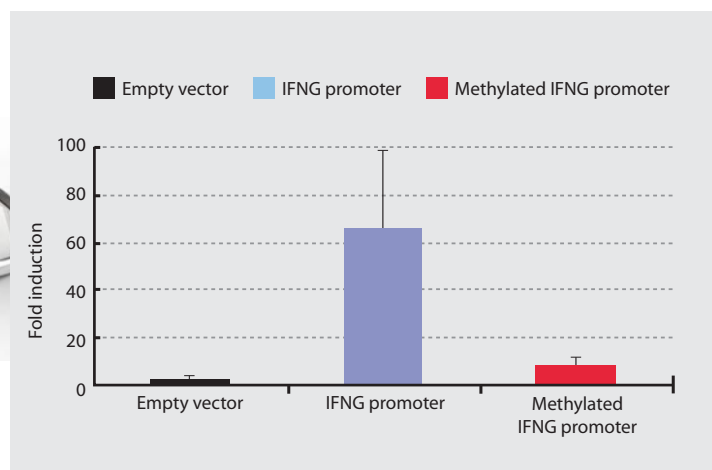


FIGURE 2: Artificial methylation of the IFNG promoter affects the level of gene transcription. Methylation of the promoter sequence at CpG sites by the enzyme SSS1 reduced promoter activity almost nine-fold (\*P=0.04).

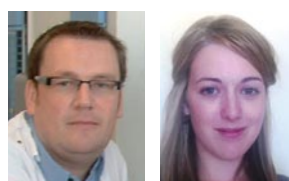
regulating any complex phenotype. Understanding and potentially manipulating epigenetic mechanisms of gene regulation holds significant promise towards developing new methods to capture traits of interest, benefit management and provide new diagnostics and/or treatments for diseases in livestock species.

*This research is being funded by Teagasc as part of a Walsh Fellowship cluster entitled 'Investigating the Genetic and Molecular Mechanisms contributing to Bovine Infectious Disease Susceptibility.'*

### References

- Kaati, G. *et al.* (2007). 'Transgenerational response to nutrition, early life circumstances and longevity'. *European Journal of Human Genetics*, **15** (7): 784-790.
- Niwa, T. *et al.* (2010). 'Inflammatory processes triggered by *Helicobacter pylori* infection cause aberrant DNA methylation in gastric epithelial cells'. *Cancer Research*, **70** (4): 1430-1440.
- Waterland, R.A. *et al.* (2006). 'Post-weaning diet affects genomic imprinting at the insulin-like growth factor 2 (Igf2) locus'. *Human Molecular Genetics*, **15** (5): 705-716.
- Weaver, I.C. *et al.* (2004). 'Epigenetic programming by maternal behavior'. *Nature Neuroscience*, **7** (8): 847-854.

Dr Kieran Meade is a senior scientist in the Animal & Bioscience Research Department. Rachael Doherty is a Teagasc Walsh Fellow working on this epigenetics project. E-mail: kieran.meade@teagasc.ie.



## Soiled water – a valuable resource

Researchers at Teagasc Moorepark, in collaboration with NUIG and UCD, have found that dairy soiled water/dilute slurry is a valuable nutrient source that can help increase farm profitability and minimise environmental impacts when managed correctly.



Lysimeters installed at Teagasc, Moorepark, to monitor nutrient leaching and  $N_2O$  emissions.



Woodchip filters used to treat soiled water for re-use to wash down yards.

Dairy soiled water/dilute slurry (hereafter referred to as soiled water) is a farmyard effluent, produced through washing down milking parlours and holding areas, that contains parlour washings, spilt milk, urine and faeces. Soiled water contains nutrients ( $0.6\text{kg}/\text{m}^3$  nitrogen [N],  $0.08\text{kg}/\text{m}^3$  phosphorous [P] and  $0.6\text{kg}/\text{m}^3$  potassium [K]) and can be used as an organic fertiliser to replace some of the mineral fertiliser used on farm, leading to cost savings for farmers and reduced risks of nutrient losses to the environment – a win-win scenario.

Currently, most farmers apply soiled water to grassland without accounting for its nutrient content. Best management strategies are needed, and research undertaken at Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, in collaboration with University College Dublin (UCD) and the National University of Ireland, Galway (NUIG), investigated two such strategies. The first was application to grassland as an organic fertiliser. The second was treatment with a woodchip filter to remove organic matter and nutrients, followed by re-use of water to wash down yards. The focus of both strategies is to recycle nutrients and/or water as efficiently as possible, while minimising environmental losses.

### Application to grassland

The fertiliser potential of soiled water was assessed in a field plot experiment on two contrasting grassland soils; a free-draining acid brown earth and a poorly drained Gleysol. Soiled water was applied at three rates (0, 15, 22,  $30\text{kgN}/\text{ha}$ ) every six weeks throughout the year to assess the optimal rate and timing. Soiled water was applied using a watering can, replicating application with a splash-plate, which is the most common application method. Calcium ammonium nitrate (CAN) was applied at the same rates and timings to allow calculation of the N fertiliser replacement value (NFRV) of soiled water (grass growth response to soiled water as a proportion of the response to CAN).

The best yield response to both soiled water and fertiliser N occurred from May to August – the time of peak grass growth potential and N requirement. To maximise uptake and yield response to N in soiled water, it should be applied during this period (Figure 1). On average, soiled water applied from February to September had an NFRV of 80%. High NFRVs were observed on both soil types, indicating a high NFRV across a range of soils. High NFRV was also observed through the summer and autumn. In contrast, NFRVs of only 15–50% have typically been found for slurry, decreasing through the growing season. Soiled water is more dilute (lower dry matter content) and infiltrates better into the soil, reducing N losses as ammonia emitted to the air and ensuring that N is delivered effectively, and more evenly, to the grass roots. Potential ammonia losses are typically highest in summer and the slow infiltration of more concentrated slurry exposes it to greater losses. Roughly two-thirds of the N in soiled water is organic and not immediately plant available. It was surprising, then, to find such high NFRVs. This may be because soiled water spreads N more evenly to a larger area of the sward, improving N uptake and yield response, compared to fertiliser pellets, which concentrate N in the area around the fertiliser pellet. Soiled water application may also stimulate release of additional plant-available soil N. Yields increased steadily with increasing soiled water application rate up to  $22\text{kg N}/\text{ha}$  and then levelled out, suggesting that around  $20\text{kg N}/\text{ha}$  (around  $35,000\text{l}/\text{ha}$ ) may be an optimal application rate. These results suggest that soiled water applied at  $22\text{kg N}/\text{ha}$  could replace  $17\text{kg N}/\text{ha}$  of CAN while maintaining the same grass production. A dairy farm of 100 cows produces around  $600\text{kg}$  of N in soiled water annually. This could replace  $480\text{kg}$  of fertiliser N,  $570\text{kg}$  of K and  $80\text{kg}$  of P (assuming 100% availability of K and P). Assuming CAN at  $\text{€}330/\text{tonne}$ , muriate of potash (50%) at  $\text{€}450/\text{tonne}$  and superphosphate (16%) at  $\text{€}425/\text{tonne}$  gives savings of  $\text{€}575/\text{year}$  in N,  $\text{€}513$  in K and  $\text{€}212$  in P – a significant potential total cost saving of  $\text{€}1,300/\text{year}$  to the farmer.

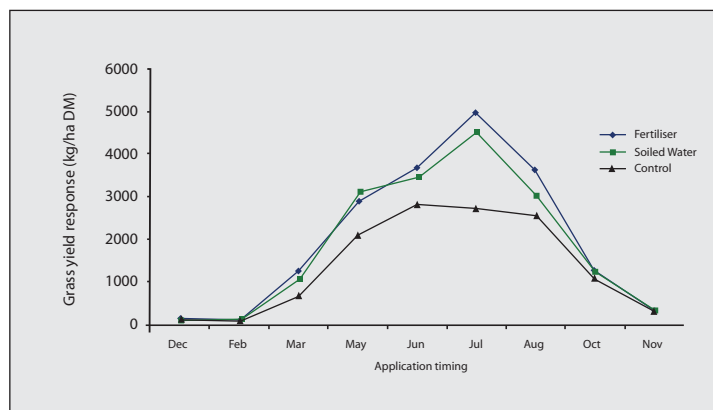


FIGURE 1: Grass dry matter yield (eight weeks' growth) for plots receiving soiled water or fertiliser (average of 15, 22 and 30kg N/ha application rates), applied at six-week intervals over a year.

### Risks of loss to the environment

The risk of nutrient loss to the environment from soiled water applied to grassland was investigated using lysimeters with the same two soils used in the plot experiment. Intact soil cores (30cm diameter by 70cm depth) were extracted and installed as lysimeters. There were four treatments; a control receiving CAN only, and soiled water substituted for CAN at the maximum legal rate (50,000l/ha every six weeks) over three time periods (May to August, September to December, January to April). All lysimeters received a total of 198kg N/ha/year. There were four replicates of each treatment. Concentrations and total fluxes of nutrients were monitored in leachate and N<sub>2</sub>O emissions were monitored using the static chamber method.

Leachate N loss for the control (12kg/ha) was higher than for treatments receiving soiled water in May to August (6.8kg/ha) and January to April (7.5kg/ha), but not different from those receiving it in September to December (12.2kg/ha) (Figure 2). Similarly, annual N<sub>2</sub>O-N emissions were lower for treatments receiving soiled water in May to August (4kg/ha) and January to April (3.9kg/ha) than those receiving it in September to December (8kg/ha) or the control (6.4kg/ha). Therefore, substituting soiled water for fertiliser N during the growing season may decrease both nitrate leaching and N<sub>2</sub>O emissions, and losses can be minimised by application during the growing season. Leachate N loss from the well-drained acid brown earth (14.9kg/ha) was higher than from the poorly drained Gleysol (4.4kg/ha) but, despite the contrasting soil type and drainage conditions, N<sub>2</sub>O emission was not significantly different.

### Filtration through woodchip

Laboratory-scale woodchip filters achieved substantial removal of chemical oxygen demand (COD) (93%) and TN (91%) from soiled water. Therefore, three farm-scale pilot woodchip filters (10 x 10m in area and 1m deep) were constructed at Moorepark to treat soiled water from 300 dairy cows over a year. A network of pipes ensured an even distribution over the surface of the filters. Each filter was loaded with 3,000l/day. Average influent concentrations of COD and TN were 5,750mg/l and 357mg/l, respectively, and decreases of 66 and 57% were achieved. Effluent concentrations remained relatively stable over the study period.

Sand filters were investigated as a secondary treatment to further clean the water for re-use. Three replicate single-layer and stratified filters were loaded at 20l/m<sup>2</sup>/day with woodchip filter effluent for 82 days. Average influent COD and TN concentrations of

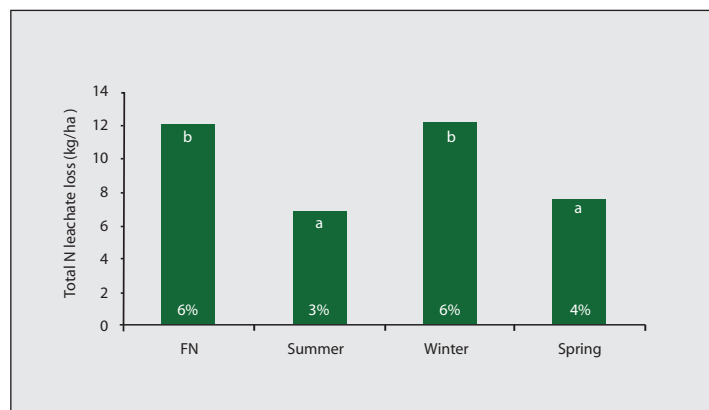


FIGURE 2: Annual total N lost in leachate from lysimeters receiving fertiliser N only (FN) and soiled water substituted for fertiliser N at different times of the year. All lysimeters received 198kg N/ha/yr in total. Columns with different letters are significantly different. N loss as a percent of total N applied is also shown.

1,991mg/l and 163mg/l, respectively, were decreased by 39 and 36% for the single-layer filters, and 56 and 57% for the stratified filters, respectively. Therefore, treatment of soiled water with a woodchip filter followed by a sand filter shows potential as a low-cost, minimal maintenance recycling system to allow re-use of water to wash down yards, decreasing water usage and generation of soiled water on farm. Eventually, filtered soiled water and spent woodchips could be land-applied, supplying nutrients and organic matter to enhance soil fertility.

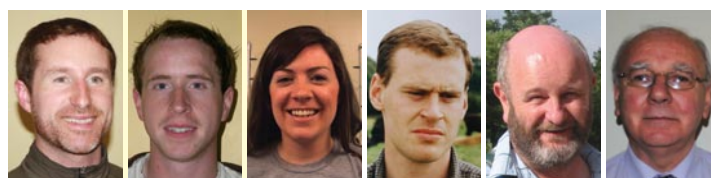
### Benefits to industry

Improved management of soiled water/dilute slurry through application at appropriate times and rates and/or treatment and re-use can help to increase farm profitability and minimise environmental impacts – a win-win scenario.

### Acknowledgements

This work has been funded by the Research Stimulus Fund of the Department of Agriculture, Fisheries and Food.

**Dr Paul Murphy** was a Research Officer in the Farm Systems Research Department, Moorepark, and is now with the Agricultural Catchments Programme, Johnstown Castle. **Denis Minogue** was a PhD student with UCD and is now a Research Officer in the Farm Systems Research Department, Grange. **Eimear Ruane** was a PhD student with NUIG. **Dr Padraig French** is head of the Farm Systems Research Department, Moorepark. Professor **Tom Bolger** is head of the School of Biology and Environmental Science, UCD. **Dr Michael Rodgers** is a lecturer in the Civil Engineering Department, NUIG.



# Improving the national breeding programme



*Identifying the genetic potential of cattle and sheep is a key goal of the Food Harvest 2020 vision for Irish agriculture.*

Teagasc, in association with the Irish Cattle Breeding Federation and Sheep Ireland, has been making strides in the development of the national genetic evaluations for cattle and sheep in Ireland.

The ultimate aim of any successful breeding programme is to increase farm profitability in a sustainable manner. This article describes the various components of a national breeding programme and uses a recent research project investigating animal price and live weight in cattle as an example. *Food Harvest 2020* (DAFF, 2010) has set out clear and ambitious targets for the beef, dairy, and sheep sectors. Genetics researchers at Teagasc work in close collaboration with industry, and are using *Food Harvest 2020* and the Teagasc Roadmaps to prioritise future research strategies. Nonetheless, genetics is only one component of the entire production system, and it is important that the type of animal bred is suited to the production systems of the future, which will rely heavily on exploiting Ireland's competitive advantage in grazed grass.

## Breeding objective

For a trait to be considered for inclusion in a breeding objective it must be either economically, socially (e.g., animal welfare) or environmentally important. Teagasc has made important contributions to the development of national breeding objectives for beef cattle (Suckler Beef Value – SBV), dairy cattle (Economic Breeding Index – EBI) and sheep (Sheep Value Index). All of the traits included in these objectives are of economic importance to Irish production systems and are optimally weighted within the objectives. The indexes include revenue-generating traits, such as carcass traits, and cost traits, such as fertility. Inclusion of the cost traits in the EBI has doubled genetic gain in overall profitability; if exploited optimally this is worth over €26 million annually. All three breeding objectives are routinely reviewed in the light of expected changes in prices and costs, as well as the availability of new data.

Obviously, the price a farmer receives for his animal will affect farm revenue. Following consultation with industry, it was decided to prioritise research on the feasibility of including animal price in the national breeding objectives for dairy and beef cattle.

## Trait measurement

The feasibility of breeding for a given trait is dictated by the availability of data, either for the trait itself (e.g., carcass lean meat yield), or a genetically related

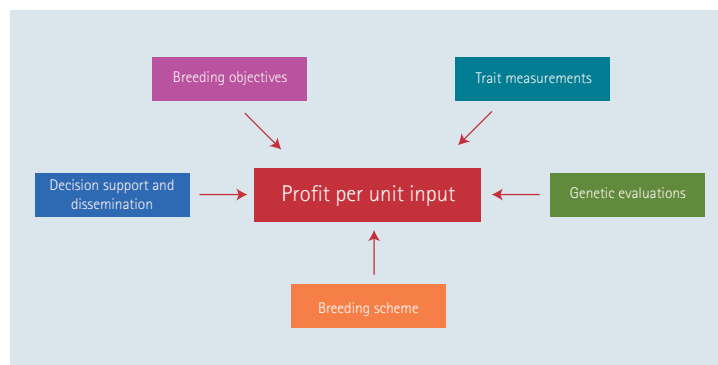
trait (e.g., ultrasound muscle depth as a predictor of carcass lean meat yield). Ideally the data should be measurable early in life, preferably also across genders, and be available at a low marginal cost.

In Ireland, an excellent cattle movement tracking system is in place; this unique system of tracking movements is captured in the Irish Cattle Breeding Federation (ICBF) database. Livestock marts remain an important marketing outlet for cattle. Approximately 1.5 million cattle, or 66.7% of total cattle movements, are sold through livestock marts annually and these data are available for genetic evaluation. No data are available on individual sheep prices.

## Genetic evaluation

A large component of genetic research is estimating the genetic variation present among traits, as well as the genetic relationships among traits. The latter is to determine if the accuracy of identifying genetically elite animals can be augmented by supplementation from alternative data sources; knowledge of the interrelationships among traits is also important to quantify the expected responses to selection – including any possible negative consequences of selection.

In order to determine if a trait is under genetic control, estimation of genetic parameters must be undertaken. This procedure requires an excellent understanding of animal science and the source of the data. As errors can occur through the recording of data, the first step of the genetic analysis involves the editing of the data (e.g., animals with unrealistic live weights or ages are removed from the data). Once the data are edited, a statistical model is developed, which reflects the underlying biology, and accounts for on-farm managerial effects and temporal trends in prices across marts, as well as other factors, such as the age of the animal. If all effects in the model are deemed to be statistically significant, then genetic analysis of the trait can be undertaken. Genetic analysis of the collected data on animal price and live weight across many thousands of animals clearly showed that genetic variation existed among animals. The proportion of differences among animals in price attributable to their genetic merit varied from 10% to 34%. Other traits routinely available, such as linear type traits, were identified as useful predictors of genetic merit for



The key components of a successful breeding programme.

animal price, thereby increasing the accuracy of estimated genetic merit. Hence, because: 1) animal price makes a large financial contribution to the profit on farm; 2) routine data are freely available; and, 3) genetic differences among animals exist, animal price will now be included in the national breeding objectives for beef and dairy.

### Breeding scheme

The fourth step in designing a successful breeding programme is identifying genetically elite parents of subsequent generations and mating these animals appropriately to ensure sustainable long-term genetic gain with minimal accumulation of inbreeding. A progeny testing scheme is the traditional breeding scheme for the genetic improvement of beef and dairy cattle and, in Ireland, is called **GENEIRELAND®**. For sheep, two different breeding initiatives were established in Ireland: the Maternal Lamb Producers (MALP) and the Central Progeny Test (CPT) flocks. The MALP flocks were established to test the robustness of the genetic evaluations across different land types and production systems, but also to provide a demonstration of the range of genetic merit among a group of rams. The CPT flock involves mating rams of various breeds and from a diverse population of performance recording flocks to a central group of ewes. Information on the resulting progeny produced that are managed in a commercial environment feeds back into the genetic evaluations and provides predictions of the genetic merit of the pedigree rams used and also their relatives. The inclusion of animal price and live weight in genomic selection breeding programmes for dairy cattle was examined using simulations. Results showed that the use of genomic information on females had the potential to increase the rate of genetic gain three-fold. Subsequent economic analysis revealed an annual cumulative benefit for the Irish dairy herd of €20 million with a cost of €0.25 million per year.

### Decision support and dissemination

Finally, the key to any successful breeding programme is to ensure that there is widespread understanding and uptake of the national evaluations by the end users. This is being achieved through dissemination of researcher results through

the national press, open days, farm walks, industry meetings and the Teagasc Advisory Service. Coupled with dissemination, decision support tools are being developed that will ensure that farmers are not overwhelmed with figures but are given clear, concise recommendations to increase genetic gain. One such decision support tool that is under development at Teagasc uses herd-level animal growth profiles as a benchmarking tool that allows farmers to compare the growth performance of their herd with contemporaries, while simultaneously adjusting for the genetic merit of the herd.

### So where to now?

Teagasc genetic research will continue to focus on all of the components of a successful breeding programme and will exploit the skills developed in one sector for use in other sectors. A good example is genomic selection, which is already implemented for dairy cattle but which can be relatively easily modified and implemented in beef; implementation in sheep is some time off. However, a prerequisite for a successful genomic selection programme is accurate breeding objectives and genetic evaluations, as well as optimal breeding programmes to exploit the technology and knowledge among the end user to implement. Therefore, most research in the short to medium term will focus on getting the basics correct.

Access to large quantities of accurately recorded data is one of the main hindrances to accurate genetic evaluations in Ireland and, therefore, consideration is being given to alternative approaches for data generation. Such approaches are utilising skills from other disciplines, such as engineering; for example, following research at Teagasc and the ICBF, data from video image analysis of carcasses will soon be included in Irish cattle genetic evaluations. The foundations for the implementation of successful national breeding programmes exist in Ireland. Research must now focus on harnessing these resources to realise the targets set out in *Food Harvest 2020*.

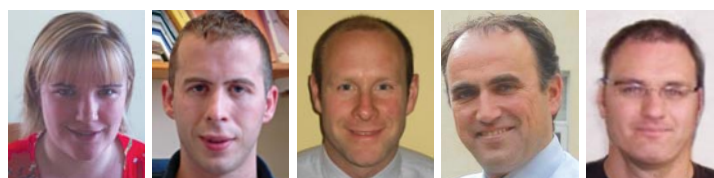
*This research is funded by the Teagasc Core Programme and the ICBF.*

### References

- DAFF.** (2010). 'Food Harvest 2020 - A vision for Irish agri-food and fisheries'. Department of Agriculture, Fisheries and Food, Dublin, Ireland - [www.agriculture.gov.ie](http://www.agriculture.gov.ie).  
Teagasc Roadmaps for the farming and food sectors are available at [www.teagasc.ie/publications](http://www.teagasc.ie/publications).  
Details on the breeding programmes can be found at [www.icbf.com/](http://www.icbf.com/) and [www.sheep.ie/](http://www.sheep.ie/).

**Nóirín McHugh** and **Dr Donagh Berry** are Research Officers at Teagasc, Animal and Bioscience Research Department, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork.

**Dr Ross Evans**, **Dr Andrew Cromie** and **Thierry Pabiou** are part of the genetics team with the ICBF and Sheep Ireland. E-mail: [noirin.mchugh@teagasc.ie](mailto:noirin.mchugh@teagasc.ie).



# Quantifying and understanding tail biting in pigs

LAURA BOYLE describes the difficulty of complying with EU legislation on tail docking because of the intractability of tail biting in pigs.

Tail biting is an aberrant behaviour performed by pigs and strongly linked to intensive production methods. The behaviour consists of two stages: stage 1 involves a pig manipulating another pig's tail in its mouth, often with little or no reaction from the recipient; and, stage 2 is the often frenzied cannibalism of the tail. While stage 1 is common under intensive conditions, the behaviour only progresses to stage 2 sporadically. Risk factors include tail length, stocking density, diet, ventilation, complexity of the housing environment and health status. This multifactorial aetiology makes tail biting an intractable problem, which causes pain and poor welfare for thousands of pigs and considerable distress for the people looking after them. Additionally, tail biting is often associated with infection, leading to abscesses on the spine and, ultimately, the condemnation of carcasses at slaughter, which has significant economic implications.

## Tail docking

Tail docking (removal of a portion or all of the pig's tail, usually within a few days of birth) is widespread in the EU (European Food Safety Authority, 2007) and has traditionally been used to reduce the potential for tail biting. However, docking is not a panacea and if circumstances are stressful enough (e.g., blocked feeder or drinker in an overcrowded pen), pigs may still bite docked tails or else resort to biting the flanks or ears. Thus, docking does not address the causes of tail biting, only the symptoms. As pigs are rarely anaesthetised for this procedure it is also an issue for pig welfare.

## Complaints to the EU

A recent report on tail biting concluded that improvements to the pig's environment (e.g. provision of substrates such as straw) can reduce the risk of tail biting (European Food Safety Authority, 2007). Tail docking is regulated under the European Communities (Welfare of Farmed Animals) Regulations 2010, which was brought into Irish law under Statutory Instrument 311 in 2010. Thus, routine tail docking is no longer permitted, and "other measures shall be taken to prevent tail biting and other vices taking into account environment and stocking densities". If these measures fail and there is evidence that injuries to other pigs' tails have occurred, then non-routine docking is permissible. In July 2009, Compassion in World Farming lodged a formal complaint with the European Commission in light

of Ireland's failure to ensure that routine tail docking is not carried out. However, in the case of tail biting, the welfare and ethical concerns associated with docking are arguably less of a problem for the pig than tail biting is later in life.

## Factory survey

We measured the actual extent of tail docking in Ireland and the prevalence of tail biting in pigs with tails of different lengths. Six abattoirs (in both Northern Ireland and the Republic of Ireland) were visited for three consecutive days each during summer 2010. The herd identification number (i.e., 'slap' number), sex, tail length (long or docked) and tail injury score of all the pigs killed in each factory on those days was recorded. The scale used to score the severity of tail biting was as follows: 0 – no evidence of tail biting; 1 – healed or mild lesions; 2 – evidence of chewing or puncture wounds, but no evidence of swelling; 3 – evidence of chewing or puncture wounds with swelling and signs of possible infection; and, 4 – partial or total loss of the tail with signs of severe infection. Inspections were conducted after the pigs came out of the scalding tank and prior to dehairing.

## High levels of tail-directed behaviour in slaughter pigs

Of the 36,963 pig carcasses inspected, less than half (41.2%) had normal (score 0) tails. The remaining 58.6% were broken down as follows: 52.5% (score 1), 5.1% (score 2), 0.62% (score 3) and 0.43% (score 4). These figures reflect an alarmingly high level of tail-directed behaviour in slaughter pigs. Admittedly, most tails received the relatively mild score of 1, which probably reflects superficial damage caused by stage 1 tail biting. Arguably, scores of 1 could also be attributed to the washing (scalding) procedure post mortem. However, the fact that male pigs had a higher proportion of score 1, 2, 3 and 4 tails than female pigs suggests that score 1 tails were not mechanically induced. This also supports the theory that males are more susceptible to being bitten. There is no disputing the aetiology of scores of 2, 3 and 4, and the fact that 6% of carcasses were affected by these severe injuries is of serious concern.

## Does docking work?

Almost all pigs had docked tails (99.1%). Although only 347 carcasses had undocked tails, a higher proportion of these received scores of 1 (59.9% vs.



Far left: Undocked pig with tail injury.

Left: Under EU legislation pigs must be provided with manipulable materials. Ideally 'toys' should be supplemented with straw, compost or wood shavings to help prevent tail biting.

52.4%;  $p < 0.01$ ) and scores greater than 1 (29.9% vs. 5.97%;  $p < 0.001$ ) compared to docked carcasses. This indicates that tail docking prevents tail biting to some extent and lends support to producers' reluctance to abandon the practice. Producers cannot, however, afford to be complacent, and the high number of docked animals affected by tail injuries suggests that there is a lot of room for improvement in housing and husbandry practices.

### Experience with undocked pigs at Moorepark

In a trial at Moorepark (224 undocked pigs in 16 pens), we found a persistently high level of tail-directed behaviour (c. 1.2 incidences/pig/hour or 16.8 incidences/pen/hour) and there were at least 12 acute outbreaks of stage 2 tail biting over nine weeks. These resulted in 35% of the pigs suffering some degree of tail amputation by the time they reached 60kg liveweight. This was in spite of excellent housing conditions, a strict intervention protocol (removal of the biting pig(s) and treatment of tail injuries) and the provision of 'toys' and chains to go some way towards meeting the environmental enrichment requirements of the pig. The experience suggests that under existing housing and husbandry conditions, tail biting could become more prevalent if tail docking is abandoned.

### Casualty pigs

The tails of pigs from the Moorepark trial were also inspected for damage at the factory after slaughter at c. 100kg. In spite of the high level of tail biting earlier in the production cycle, none received scores higher than 2, and there were no carcass condemnations for abscessation. In contrast, 161 pigs inspected (0.43%) in the factory survey received a score of 4. For injuries to become this severe it is unlikely that the affected pigs had been isolated from the biter(s) and/or received any treatment. Such serious tail damage is entirely avoidable, as demonstrated by the Moorepark study. Even more worryingly, although scores of 4 were only detected in 0.43% of pigs, they were spread across 34% of the 231 farms sampled. Pigs with such severe injuries should not knowingly be presented for slaughter as they represent a threat to food safety and in any case are likely to cause additional suffering. These pigs should be considered as casualty animals and euthanised on farm.

### Future research

Given that routine tail docking is now prohibited by law, more effort needs to be made to prevent the causes of tail biting. Although challenging under current production practices, there is great potential for improvement of the pigs' environment. Additional changes in the way in which condemnations are communicated to producers could play a huge role in improving the on-farm treatment of badly bitten pigs (i.e., indicate that carcasses that were condemned were also tail bitten). Further work in this area will develop the issue of carcass condemnation as a welfare outcome for pigs, determine the costs of carcass condemnation arising from tail biting, and examine the implications of tail-directed behaviour for meat quality.

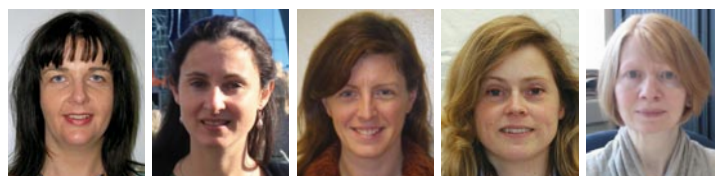
### Reference

**European Food Safety Authority.** (2007). 'The risks associated with tail biting in pigs and possible means to reduce the need for tail docking considering the different housing and husbandry systems.' *The EFSA Journal*, **611**: 1-13.

**Dr Laura Boyle** is a Senior Research Officer in animal behaviour and welfare with the Pig Development Department, Teagasc Moorepark. **Dayane Lemos Teixeira** is a PhD candidate at the University of Zaragoza in Spain.

**Dr Keelin O'Driscoll** is a Marie Curie Experienced Researcher at the Teagasc, Animal & Grassland Research and Innovation Centre in Grange.

**Dr Niamh O'Connell** is with the School of Biological Sciences in Queen's University Belfast and manages the Farm Animal Welfare Research Unit at the Agri-Food and Biosciences Institute at Hillsborough. **Dr Alison Hanlon** is with the School of Agriculture, Food Science & Veterinary Medicine at UCD. E-mail: laura.boyle@teagasc.ie.



# Measuring up for innovation

A recent Teagasc study challenges current views and measures of innovation in the food industry.

**W**hat gets measured gets done', according to the saying. But perhaps one should question 'how' things are measured? Recent Teagasc research suggests that traditional measures of innovation within the food sector may not be giving the full picture of what's really going on. Using measures focused on innovation outputs, and encompassing non science-based forms of innovation, may provide greater insight into this vital industry. Furthermore, developing a sector-specific innovation index could support more effective resource allocation to the industry and facilitate innovation. Innovation in this article is understood in its broadest context, i.e., encompassing radical and incremental innovation and technological and organisational innovation.

## Measuring innovation: an overview

Innovation is traditionally measured by metrics such as research and development (R&D) expenditure and patent counts. Such metrics categorise the food industry as a low level innovator. For example, food business expenditure on R&D is reported to be among the lowest of all industries (Forfás, 2007). Furthermore, unlike other sectors such as medical instruments and pharmaceuticals, investment, internationally, has not been found to have increased significantly in the last decade (Winger and Wall, 2006). The reported low level of innovation activity may be attributed to the large proportion of small and medium enterprises (SMEs) within the sector that may not have resources for, or a background in, R&D. However, an alternative perspective is that current measures may underestimate the true level of activity, and that the food industry is not in fact a low level innovator. Alternative measures used to examine innovation activity within the food sector in a recent Teagasc survey of food companies suggest that the food industry is highly innovative, indicating that there could be significant levels of 'hidden innovation' within the industry.

Traditional measures of innovation are already recognised as flawed. For example, while internationally harmonised R&D expenditure statistics are easy to obtain and facilitate cross-country and cross-sector comparison, such statistics do not indicate whether the original innovation investment achieved its intended goal. They also exclude other innovation inputs (e.g., capital expenditure on new process equipment). Patent counts are criticised as they may portray a limited picture of innovation in countries dominated by service industries or sectors that have lower propensities to patent, i.e., they exclude non-patented innovations. Further limitations are that they may not be reflective of economic value and they can be purposely misleading, as firms are known to make strategic decisions to deceive



competitors. These limitations may have different impacts in different sectors (e.g., those dominated by high levels of SMEs or high levels of services), and so may not result in fair comparisons across sectors. More importantly, however, these measures may not take account of the types of innovations that contribute most directly to the real practice and performance of a sector.

Measuring innovation outputs (e.g., product/process innovations) may be more useful as it gives an indication of whether the original innovation goal was achieved. Similarly, broadening the scope of the measure to include measures of organisational innovation may be particularly revealing when assessing innovation activity in smaller companies. A further reason for including measures of organisational and marketing innovations is that such innovations facilitate and highlight the need for technological innovation (OECD, 2005) and are, therefore, an integral part of the science-based innovation process.

So what measures of innovation are appropriate for the Irish food industry? Without doubt the need for science-based innovation with metrics such as expenditure on R&D and patent counts is important in the commodity sector where, for example, radical process innovations have the potential to reduce costs and support cost competitiveness.

Such science-based innovation is also crucial to enable Irish food companies to participate in high-value growing markets such as those based on nutraceuticals and functional foods. But is this type of innovation equally important for companies seeking to gain increasing market share in the mature European food market, which is dominated by large retailers? And what about the constraints the sector faces in the (lack of) openness by consumers to radical food-related concepts or due to tight margins? Could incremental product innovations, marketing innovations and organisational innovations be the types of innovation that matter most for some of these companies? While this study does not attempt to prescribe what type of innovation matters for different companies, it does attempt to challenge current views and measures regarding innovation in the food industry.

## Field research

Data for this study were collected through a postal survey. The questionnaire was based on a literature review and in-depth interviews with key industry representatives to ensure that the theoretical underpinning of the questionnaire was appropriate to the Irish food SME context. A satisfactory response rate (30%) was achieved. Respondents (n=127) were broadly representative of the Irish food industry in terms of sector, size, location and export status.



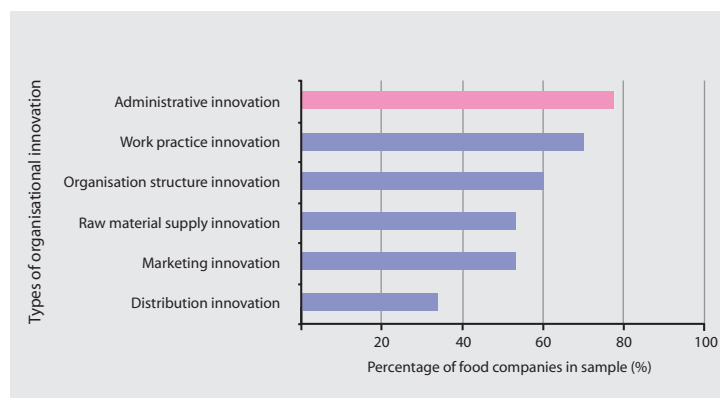


FIGURE 1: Prevalence of different types of organisational innovation in the sample of Irish food companies.

### Reported level and type of innovation

Traditional measures used within the study continued to portray an industry with low levels of innovation activity. For example, patent use was low, with only one in five companies reporting using patents. However, when innovation was measured in terms of outputs from technological innovation, high levels of activity were reported within the sample.

More than three out of four companies claimed to have undertaken product innovation within the last three years, while more than one in two claimed to have undertaken product and process innovation. High levels of organisational and marketing innovation were also reported (Figure 1).

These results support findings from other studies that indicated a supporting relationship between involvement in technological innovation and other types of innovation, and reinforce the importance of being involved in different innovation spheres. As expected, across product, process and packaging innovations, incremental or 'new to firm' innovations predominated over more radical 'new to industry' innovations (Figure 2). However, while radical process and packaging innovations were particularly uncommon, new to industry innovations were recorded across the three categories.

### Benefits to industry

This research finds that different measures of innovation give a different perspective on innovation activities within the food industry. Low levels of expenditure on R&D and low patent use indicate low levels of innovation activities. However, this is at odds with high levels of technological and organisational innovation. The National Endowment for Science, Technology and the Arts (NESTA – an independent body in the UK, 2007) suggested that an 'industry-relevant' innovation index would be best able to identify the innovations that were actually making a difference. This would greatly improve policy development, as it would highlight areas to target more efficiently. While such indices have been created for some industries (such as oil production, retail banking and construction), a food industry-specific index remains elusive. Studies such as the work presented here can contribute to the development of such an index. By moving to a measurement method that incorporates such suggestions, in addition to those highlighted by the hidden innovation work undertaken by NESTA, it is probable that a very different picture of the level of innovation in food companies would emerge. Building on this, as areas of particular relevance come to light, more specific targeting

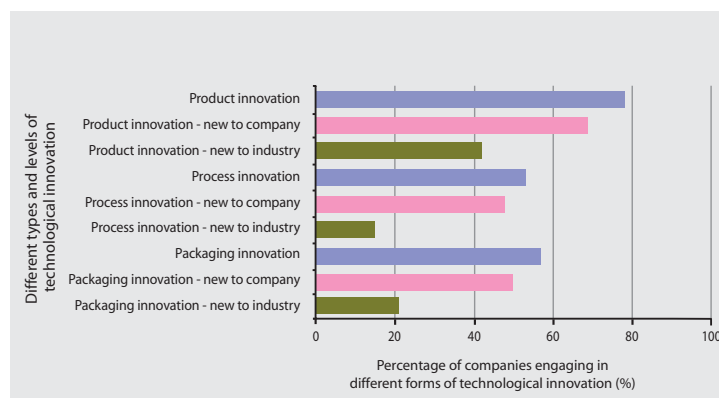


FIGURE 2: Prevalence of different types and levels of technological innovation in the sample of Irish food companies.

of resources would be facilitated. This would improve the efficiency of resource usage and thus contribute to a higher return on investment in the future. As a result, the future sustainability of what is a vital industry to the economy could be better supported.

### Acknowledgements

This research is funded by FIRM (Food Institutional Research Measure) through the Irish Department of Agriculture, Fisheries & Food under the National Development Plan 2007-2013 and is part of a larger project examining consumer and industry acceptance of a number of novel food technologies.

### References

- Forfás. (2007). 'Research & Development Performance in the Business Sector Ireland 2005/6'. Science and Technology Indicators Unit, Dublin.
- National Endowment for Science, Technology and the Arts (NESTA). (2007). 'Hidden innovation: How hidden innovation happens in six 'low innovation' sectors'. Research Report: June 2007, UK.
- OECD. (2005). 'The Measurement of Scientific and Technological Activities: Guidelines for Collecting and Interpreting Innovation Data: Oslo Manual'. Paris, France: OECD.
- Winger, R. and Wall, G. (2006). 'Food product innovation – A background paper'. Food and Agriculture Organisation of the United Nations.

**Gráinne Kavanagh** was a Walsh Fellow at the Department of Agrifood Business and Spatial Analysis. **Dr Maeve Henchion** is Head of the Department of Agrifood Business and Spatial Analysis. **Dr Mary McCarthy** is a Senior Lecturer in the Food Business and Development Department, University College Cork. **Dr Gwilym Williams** is a lecturer in the School of Biological Sciences, Dublin Institute of Technology. E-mail: maeve.henchion@teagasc.ie.



# Territorial cohesion: implications for agriculture policy in the EU

DAVID MEREDITH, Spatial Analysis Unit, REDP, describes how EU agricultural development policies have moved from focusing on balanced growth towards balanced development emphasis. This change holds significant potential for bottom-up led rural development.

## The EU: an evolving policy framework

The forthcoming review of the Common Agriculture Policy (CAP) will take place within a strategic context that is shaped by new policy provisions that are part of the Treaty of Lisbon. From the perspective of rural areas and agriculture, the extension of the Social and Economic Cohesion Policy to include territorial cohesion holds a number of implications. This article provides an overview of the emergence of this concept and outlines some of the implications for the CAP.

## The challenge of European regional diversity

From the perspective of EU economic policy, the introduction of the Single European Market and European Monetary Union are viewed as having led to greater economic and social integration. Internal borders between member states and/or regions became less relevant as "more intensive [spatial] relationships and inter-dependencies" emerged (CEC, 1999, p.7). This particular perspective is drawn from a broad body of geographic, spatial planning and policy research exploring the implications and impacts of EU economic and political integration (Amin *et al.*, 1992; Begg, 1992; Chicoye, 1992; Moulaert, 1996; Quevit, 1992; Steinle, 1992).

The analysis identifies centripetal forces operating at the continental scale, resulting in growing social, economic and demographic imbalances between a core area identified as the zone of global economic integration and the rest of the EU. The core, or pentagon as it is referred to in the European Spatial Development Perspectives (CEC, 1999; CEC, 2004; CEC, 2007), extends between London, Paris, Milan, Munich and Hamburg. This zone is characterised as offering "strong global economic functions and services, which enable a high income level and a well-developed infrastructure" (CEC, 1999, p.20). Beyond these spaces is "an increasingly large periphery" (CEC, 1999, p.20). This perspective of Europe's regions also reflects the increased regional diversity that came with enlargement of the EU to 27 member states. Most of the new members have extensive rural regions that, economically, are highly dependent on the agriculture sector. Restructuring of agriculture in the face of greater competition within domestic and international markets has resulted in reduced employment opportunities within the sector and, consequently, out-migration, particularly of younger persons. Within existing member states, processes of economic restructuring resulted in spatially differentiated outcomes, with some regions growing rapidly, while others stagnated or declined. In response, the Social and Economic Cohesion Policy evolved during the 1990s and early years of the new millennium following the recognition that economic processes influencing and operating within the Union were resulting in significant divergence in regional economic performance. During this period a number of EU reports drew attention to the diversity of regions within the EU, their opportunities and the constraints to their development (CEC, 1999; CEC, 2004; CEC, 2007). While these reports increasingly advocated an integrated approach to regional development, their real significance lies in the shift away from an approach

that saw improved accessibility, i.e., better roads, as the solution to regional underdevelopment. Within the new approach, European space is conceptualised as comprising, geographically, a relatively small core and substantial periphery. The core has a range of social and agglomerative advantages that facilitate further growth and development. Contrasting with this is the periphery, which is viewed as facing significant economic and demographic challenges. At the sub-continental scale or national level, space is conceptualised as being organised along similar lines, with core urban regions and underdeveloped, rural, peripheries. Importantly, the periphery is not viewed as a single socially and economically homogenous space that is confronted with identical challenges. Rather, peripheral regions are seen as highly diverse, with different types of regions having different types of potential for social and economic development. The challenge, from both EU and national perspectives, is to foster and enhance socio-economic development of all regions, thereby ensuring greater cohesion without undermining the capacity of the core. In response to this challenge, the member states have given the EU responsibility for territorial cohesion.

## Territorial cohesion

With the ratification of the Treaty of Lisbon in December 2009, the EU gained legal competence for territorial cohesion. This is generally defined as supporting balanced regional development through the valorisation of the socio-economic potential inherent within regions. Though sounding mundane, this approach marks a radical departure from the past. Rather than advocating redistributive measures, or balanced growth, to stimulate economic development, policy measures will in future seek to facilitate the development of 'potential'. The shift in emphasis from balanced growth, which was central to the underlying aim of the Social and Cohesion Policy, to balanced development, is significant. It represents a reflection that the EU does not have the resources, nor, increasingly, do individual member states, to target development to specific regions by offering direct aid. Rather, emphasis is given to fostering the potential associated with different places. Potential is generally defined as the capacity – incorporating physical, natural and human – of regions to develop. While it is envisaged that potential is activated within each region, an element of a region's potential is determined by how it integrates into wider space(s) of production. As a consequence, social and economic development driven from the bottom up is seen to contribute to greater interaction with other places and, hence, to contribute to territorial cohesion. This is a key element of both the Europe 2020 strategy, which prioritises inclusive growth, resulting in a high-employment economy delivering social and territorial cohesion, and the associated Territorial Agenda 2020 strategy (CEC, 2010). The latter provides strategic guidelines for territorial development, fostering integration of territorial elements within different policies, i.e., the CAP and regional policies, at all governance levels and to ensure implementation of the Europe 2020 Strategy according to territorial cohesion principles (Eurostat, 2010).

### Territorial cohesion: the role of agriculture

Rather than take a blanket approach, the member states have agreed that specific types of regions will be the focus of territorial cohesion. These are specified in Article 178 of the Treaty of Lisbon and include 'rural areas'. While a definition of what constitutes 'rural' is not provided in the Treaty text, a number of major EU-funded research projects have undertaken detailed analysis of different approaches to the identification and classification of rural areas. The European Commission (Directorate General Agriculture) commonly uses the Organisation for Economic Co-operation and Development's approach, which utilises an analysis of regional population density to determine whether, and the extent to which, regions are rural or not. This approach has evolved in recent years to incorporate a variety of other indicators, including population change and the importance of agriculture and other sectors to the economy. The resulting maps of different types of rural regions highlight the diversity of opportunities and challenges facing the EU in terms of fostering territorial cohesion. From an Irish perspective, what is apparent from this research is the rural nature of most regions compared to the UK, the Netherlands and Germany (Figure 1). Applying the balanced development approach that is central to territorial cohesion necessitates the activation of the potential that exists within regions and that is associated with interaction with other regions. The agriculture sector has a clear role to play in delivering on this objective. In addition to the obvious importance of agricultural activities to the social and economic development of rural areas, the sector plays a significant role in the development of linkages to other regions through the functioning of commodity supply chains. Furthermore, farming also plays an important role in the creation of potential in other economic sectors, particularly those that draw on public goods, i.e., culturally significant landscapes. This, in turn, gives rise to other types of networks (tourists) linking rural areas to other places, whether they are proximal or geographically extended.

### Challenge for agricultural policy

The approach of developing local or endogenous potential advocated within the balanced development concept is directly comparable to the EU's rural development approach. This takes individual territories, i.e., LEADER areas, and supports bottom-up initiatives to valorise local resources for economic development purposes. The challenge for agricultural policy will, in future, be to ensure greater co-ordination of policy objectives and strategic measures to ensure that they are targeted at developing the agricultural potential of individual regions rather than assuming that all regions share the same potential and opportunities.

### References

- Amin, A., Charles D.R. and Howells, J. (1992). 'Corporate Restructuring and Cohesion in the New Europe'. *Regional Studies*, 26: 319-331.
- Begg, I. (1992). 'The Spatial Impact of Completion of the EC Internal Market for Financial Services'. *Regional Studies*, 26: 333-347.
- CEC. (1999). 'ESDP – European Spatial Development Perspective: towards balanced and sustainable development of the territory of the European Union'. Luxembourg: European Commission.
- CEC. (2004). 'A new partnership for cohesion: Third report on economic and social cohesion'. Luxembourg Publications Office of the European Union.
- CEC. (2007). 'Growing Regions, growing Europe: Fourth report on economic and social cohesion'. Luxembourg Publications Office of the European Union.
- CEC. (2010). 'EUROPE 2020: A strategy for smart, sustainable and inclusive growth'. Brussels: European Commission.

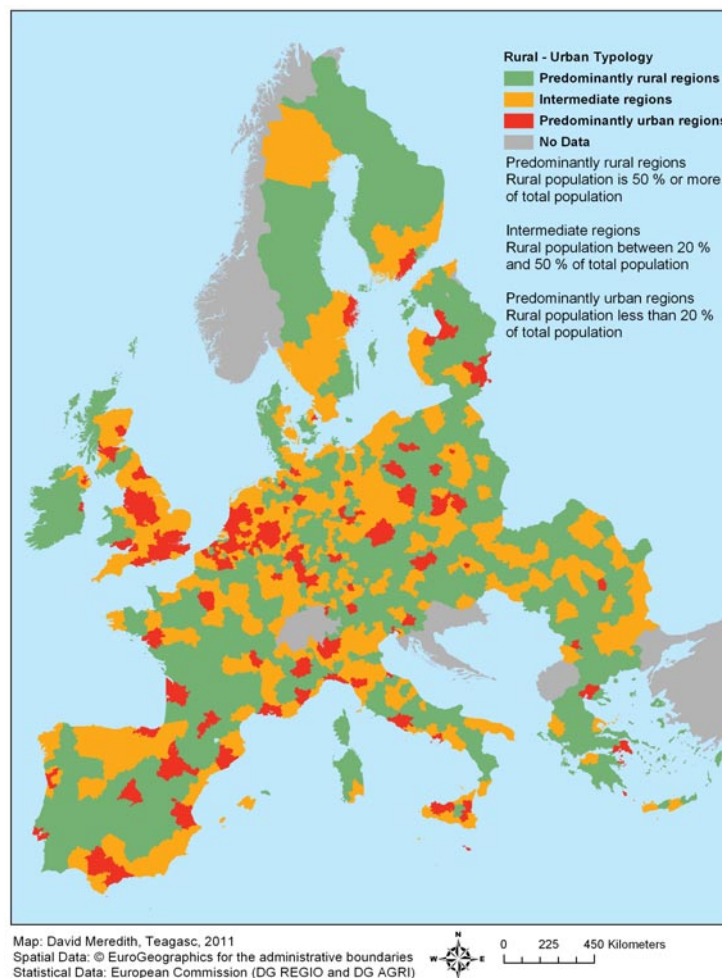


FIGURE 1: Rural-urban typology of selected countries within the EU.

- Chicoye, C. (1992). 'Regional Impact of the Single European Market in France'. *Regional Studies*, 26: 407-411.
- Eurostat. (2010). 'Eurostat regional yearbook 2010: A revised urban-rural typology. 239-249'. Luxembourg: Publications Office of the European Union.
- Moulaert, F. (1996). 'Rediscovering spatial inequality in Europe: Building blocks for an appropriate 'regulationist' analytical framework'. *Environment and Planning D-Society & Space*, 14: 155-179.
- Quevit, M. (1992). 'The Regional Impact of the Internal Market: A comparative analysis of traditional industrial regions and lagging regions'. *Regional Studies*, 26: 349-360.
- Steinle, W. J. (1992). 'Regional Competitiveness and the Single Market'. *Regional Studies*, 26: 307-318.

David Meredith is a Senior Research Officer in the Spatial Analysis Unit, Rural Economy and Development Programme, Teagasc, Ashtown, Dublin 17.  
E-mail: david.meredith@teagasc.ie.



# T Events

## SEPTEMBER

September 4-8 *Dublin Castle Conference Centre*

### International Conference: Eucarpia Forage and Amenity Grasses Section Meeting

susanne.barth@teagasc.ie www.eucarpia.org

September 7 *Keadeen Hotel, Newbridge*

### National Tillage Crops Forum

Teagasc invites tillage growers, merchants and all involved in the Irish grain industry to the National Tillage Crops Forum. Topics will include: market prospects; greater market transparency; crop budgets and programme planning; winter cereal varieties; making oilseed rape profitable; and, adding value to cereals.  
www.teagasc.ie/events

September 12-15 *Dublin*

### 7th International Conference on Predictive Modelling of Food Quality and Safety (ICPMF7)

This conference will bring together leading academics, research scientists and food professionals who are currently developing and using simulation and optimisation tools to enhance the quality and safety of food. This event also aims at attracting various stakeholders throughout the food chain.  
www.icpmf.org/2011

September 14 *Teagasc Food Research Centre, Ashtown*

### Food by-products – potential uses, recovering nutrients and maximising their value

The aim of this workshop is to show ways of adding value to food by-products. It will focus on: beef; glycoalkaloids from potato peel; brassicas, e.g., cabbages; apiaceae, e.g., carrots; alliums, e.g., onions; brewer's spent grain – a co-product of the brewing industry; apple pomace from the juice and cider industries; and, marine by-products.  
info@relay.teagasc.ie

September 14-16 *The Mansion House, Dublin*

### Catchment Science 2011

Entitled 'Catchment scale research and evaluation for agriculture and water quality', this international conference is aimed at scientists, policymakers, farmers and managers. Jointly hosted by the Irish Agricultural Catchments Programme (Teagasc/DAFF) and the UK Demonstration Test Catchments Projects (Defra/EA).  
catchments@teagasc.ie www.teagasc.ie/catchmentscience

September 22 *Teagasc Food Research Centre, Ashtown*

### Making ends meet – opportunities for the Irish beef industry

This workshop addresses a range of key issues facing the beef industry, including quality, safety, nutrition, carbon footprint, authenticity, traceability, functional foods, mining for meat bioactives and the targets for *Harvest 2020*.  
info@relay.teagasc.ie

September 28-29 *Teagasc Food Research Centre, Moorepark*

### Cheese Symposium 2011

This symposium aims to cover the most recent fundamental and applied scientific research developments in the areas of: flavour development; diversification; health and nutrition; and, fat and/or salt reduction in cheese. It will provide a forum for academia and industry to share experiences on developments and applications in research.  
Niamh O'Brien 025-42313 cheesesyposium2011@teagasc.ie

September 29 *Teagasc Food Research Centre, Ashtown, Dublin 15*

### Strategies to Control *Campylobacter* in Poultry

This international conference and demonstration event will include the launch of the safe food *Campylobacter* Network and will feature presentations on: prevalence and control in poultry; risk-based standards; public health issues; and, antibiotic resistance. This event is aimed at poultry producers and processors, veterinarians, catering personnel, public health specialists, regulators, food safety microbiologists, etc.  
margaret.hennessy@teagasc.ie

September 29, 11.00am and 2.00pm *Teagasc Grange*

### Derrypatrick Beef Open Day

www.teagasc.ie/events

## OCTOBER

October 6 *Teagasc Food Research Centre, Ashtown, Dublin 15*

### International Conference: *Salmonella* in Pork Production

This conference will feature presentations by international experts, and topics will include prevalence, risk factors, risk assessment and control. Pork producers and processors, veterinarians, public health specialists, regulator personnel, food safety microbiologists, etc., will find this event both informative and thought provoking.  
margaret.hennessy@teagasc.ie

October 10-12 *Burlington Hotel, Dublin*

### 4th International Symposium on Animal Functional Genomics

This symposium will provide an exciting opportunity for scientists from a wide range of disciplines to meet and discuss the latest developments in the fast-moving field of animal functional genomics. Topics will include: application of new genomics technologies; computational biology and bioinformatics; and, systems biology.  
http://isafg2011.org/isafg\_announcement.pdf

October 19 *Hodson Bay Hotel, Athlone*

### The National Rural Development Conference 2011

Jointly organised by the National Rural Network and Teagasc, this conference will explore the interface between agriculture and economic development in rural areas.  
david.meredith@teagasc.ie

October 20 *Teagasc Food Research Centre Ashtown*

### Safe food Verocytotoxigenic *E. coli* Network International Conference

geraldine.duffy@teagasc.ie

October 21 *Teagasc Food Research Centre, Moorepark, Fermoy, Co. Cork*

### 4th Glycoscience Ireland Meeting

Glycoscience Ireland aims to encourage inter-disciplinary collaboration between Irish glycoscientists, biologists, chemists, engineers, information scientists and clinicians. This year's meeting will focus on food glycobiology, and topics will include: production of complex polysaccharides by human probiotic strains; anti-infective food-sourced oligosaccharides; and, specific dietary glycans for infant nutrition.  
glycoscienceireland2011@teagasc.ie  
www.glycoscienceireland.ie/conference.html

## NOVEMBER

November 10 *Teagasc Food Research Centre, Ashtown*

### Microbial challenges in the food chain – The impact of food processing stresses, antibiotic and biocide resistance

At this event, national and international speakers will focus on: pathogen persistence in the food processing environment; antibiotic resistance in foodborne pathogens; and, biocide resistance in foodborne pathogens.  
breda.mulvihill@teagasc.ie

November 13-20

### Science Week 2011

Teagasc will hold a series of Science Week events at its research centres nationwide.

The annual Walsh Fellowships seminar will take place in the RDS on November 8.  
catriona.boyle@teagasc.ie www.teagasc.ie/events www.scienceweek.ie

November 15 *Rochestown Park Hotel, Rochestown, Co. Cork.*  
November 16 *Hodson Bay Hotel, Athlone, Co. Roscommon.*

### National Dairy Conference

Conference theme: The Irish Dairy Industry: To 2015 and Beyond.

November 17 *Teagasc Food Research Centre Ashtown*

### Product Shelf-life and Microbial Criteria

pat.daly@teagasc.ie

November 24-25 *Ashtown, Dublin 15*

### Agricultural Economics Society of Ireland – Annual Conference and AESI Young Researcher Seminar

Topics at this conference will include agriculture, the environment, rural development, food marketing, supply chain management, land use and development economics. The AESI Young Researcher Seminar 2011 will be held on Friday November 25, and will provide postgraduate students with the opportunity to present their research findings to an audience of their peers.  
secretary@aesii.ie www.aesii.ie

## 2012

### Dublin City of Science 2012

Dublin has been chosen to host Europe's largest science conference, ESOF 2012 (Euroscience Open Forum), from July 11-15, 2012. To celebrate this prestigious international event, City of Science 2012, a programme of science-related events and activities, will run throughout the year across the island of Ireland. Teagasc will be running a series of events during 2012 in support of City of Science 2012. For more details on Teagasc's involvement see:  
http://www.teagasc.ie/research/cityofscience/