TEAGASC

Research

Volume 8: Number 4. Winter 2013 ISSN 1649-8917

Research and innovation news at Teagasc www.teagasc.ie

Monitoring grass from space

using satellite imaging to observe and predict grass growth rates

Animal breeding using DNA technologies

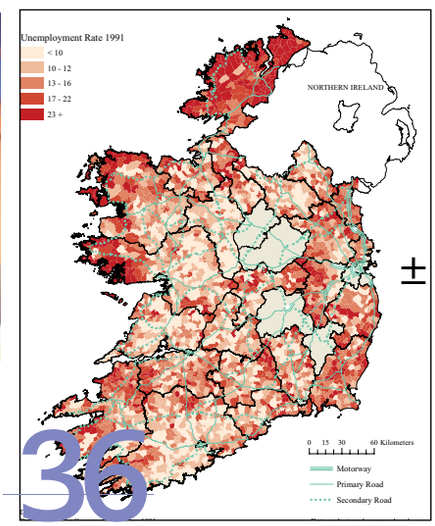
Drain, drain, sustain

Reshaping the human body using whey proteins

teagasc

Agriculture and Food Development Authority

Contents



Teagasc | Oak Park | Carlow

Agriculture and Food Development Authority

National Development Plan 2007 - 2013

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

EDITOR Catriona Boyle 059-918 3419 catriona.boyle@teagasc.ie
SUBSCRIPTIONS: alison.maloney@teagasc.ie

Teagasc welcomes launch of Horizon 2020

The launch of Horizon 2020 is a very welcome and very significant initiative for EU citizens, enterprises and research organisations like Teagasc. Details of the EU's research funding programme are given in an article in this issue and, with the first call just open, researchers in Teagasc and elsewhere now have the first opportunity to seek funding in this exciting new progamme. The benefits of involvement in Horizon 2020 are much more than just funding. It provides an opportunity to collaborate with other strong research groups across Europe and beyond, and this leverages far more knowledge and innovation than we could hope to achieve with our own resources. Ireland was quite successful in FP7, winning almost €600 million of funding. The Government has set an ambitious target for Horizon 2020 funding of €1.25 billion. Over the next seven years of the programme, our researchers will be actively seeking funding and collaborations in areas that match our strategic priorities.

The Irish research base is currently strong. The Government's commitment to research has remained steadfast, and is exemplified by the recent announcement of €26 million of research-funding investment by the Department of Agriculture, Food and the Marine (with over €10 million of this awarded to Teagasc researchers). As with EU funding, competitive national funding drives collaboration among researchers in different Irish institutes, and increases research capacity. For Teagasc, this externally-funded research must link to our remit and strategic goals. While the benefits of external competitive funding are clear, it is also very important for Teagasc to maintain a balance of programme and competitive funding so that we can deliver coherently on our mandate of meeting the research needs of Ireland's agriculture and food sector. In that regard, the experience in New Zealand is interesting. Research funding had been almost completely channelled through competitive schemes, but recently, programme funding to Crown Research Institutes like AgResearch and Landcare has been re-established. Therefore, while Teagasc will compete strongly for Horizon 2020 funding (and national competitive funding), it is vital that we maintain a good balance between programme and external competitive funding.

Dr Frank O'Mara
Director of Research, Teagasc
Teagasc Head Office, Oak Park, Carlow

Cuireann Teagasc fáilte roimh lainseáil Fhís 2020

Is tionscnamh an-dearfach agus an-suntasach é lainseáil Fhís 2020 do shaoránaigh, d'fhiontair agus d'eagraíochtaí taighde an AE amhail Teagasc. Tá sonraí maidir le clár maoiniúcháin um thaighde an AE ar fáil in alt san eagrán seo, agus leis an gcéad ghlao go díreach i ndiaidh oscailt, tá an chéad deis ag taighdeoirí i dTeagasc agus in áiteanna eile anois maoiniú a lorg sa chlár úr corraitheach seo. Tá i bhfad níos mó tairbhí ag baint le rannpháirtíocht i bhFís 2020 ná maoiniú amháin. Soláthraítear deis ann chun comhoibriú le grúpaí taighde láidre ar fud na hEorpa agus níos faide i gcéin, agus soláthraíonn sé sin níos mó eolais agus nuálaíochta ná mar a bheimis ag súil leis chun ár n-acmhainní féin a fháil. D'éirigh go measartha maith le hÉirinn in FP7, ag gnóthú beagnach €600 milliún i maoiniú. Tá sprioc uaillmhianach leagtha amach ag an Rialtas maidir le maoiniú Fhís 2020 de €1.25 billiún. Thar an gcéad seacht mbliana eile den chlár, beidh maoiniú agus comhoibriú á lorg go gníomhach ag ár dtaighdeoirí i réimsí atá comhoiriúnach lenár dtosaíochtaí straitéiseacha.

Tá bonn taighde na hÉireann láidir faoi láthair. Tá tiomantas an rialtais don taighde fós buansheasmhach, agus tá an fógra le déanaí de €26 milliún d'infheistíocht um maoiniú taighde ón Roinn Talmhaíochta, Bia agus na Mara (ar deonaíodh os cionn €10 milliún de do thaighdeoirí Teagasc) ina mhacasamhail. Mar atá sé le maoiniú an AE, spreagann maoiniú náisiúnta iomaíoch comhoibriú i measc taighdeoirí in institiúidí éagsúla Éireannacha, agus méadaítear an acmhainn taighde. Maidir le Teagasc, ní mór an taighde a mhaoinítear go seachtrach a bheith nasctha lenár sainchúram agus lenár spriocanna straitéiseacha. Cé go bhfuil na tairbhí a fhaightear as maoiniú iomaíoch seachtrach soiléir, tá sé an-tábhachtach do Teagasc chomh maith cothromaíocht idir maoiniú clár agus maoiniú iomaíoch a choinneáil ionas go mbeimid ábalta ár sainordú um fhreastal ar riachtanais taighde earnáil talmhaíochta agus bia na hÉireann a sheachadadh go comhleanúnach. Maidir leis sin, tá an t-eispéireas sa Nua-Shéalainn suimiúil. Fuarthas beagnach formhór an mhaoiniúcháin taighde trí scéimeanna iomaíocha, ach le déanaí, rinneadh maoiniú clár d'Institiúidí Taighde na Corónach (Crown Research Institutes) amhail AgResearch agus Landcare a athbhunú. Dá bhrí sin, cé go rachaidh Teagasc san iomaíocht go láidir maidir le maoiniú Fhís 2020 (agus maoiniú náisiúnta iomaíoch), tá sé ríthábhachtach go gcoinneoimid dea-chothromaíocht idir maoiniú clár agus maoiniú iomaíoch seachtrach.

An Dr. Frank O'Mara
Stiúrthóir Taighde, Teagasc
Príomhoifig Taighde, Páirc na Darach, Ceatharlach

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:
IFP Media, 31 Deansgrange Road, Blackrock, Co. Dublin.
t 01-289 3305 **f** 01-289 6406 **www.ifpmedia.com**
Design: Martin Whelan
Editorial: Oonagh O'Mahony

TResearch is available online as PDF or digital edition, see www.teagascie/publications/tresearch/ or scan with QR code reader.

Scan with QR code reader

Be social! Connect with Teagasc http://www.teagasc.ie/news/social_media.asp
Cover image credit: NASA/Goddard Space Flight Center Conceptual Image Lab.

Dr Thia Hennessy

Thia Hennessy is head of the Agricultural Economics and Farm Surveys Department of Teagasc. In this role, Thia is responsible for the Teagasc National Farm Survey, which produces the national official statistics on input, output and income in farming in Ireland. She also oversees Teagasc's agricultural economic research programme.

Thia has worked as an economist with Teagasc since 1998, during which time she developed economic models to assess the impact of agricultural and environmental policies on farm incomes and the sustainability of farming. Arising from this research, she has published over 40 journal articles, as well as numerous popular media articles.

Thia has participated in a several international research projects, funded through the EU's Framework Programme, and she has coordinated five major economic research projects funded through the Irish Department of Agriculture's Stimulus Fund. She has also supervised a number of graduate students at Masters and PhD level.

Thia completed her primary degree in Economics and Finance at the National University of Ireland, Maynooth, in 1996. She followed on from this with a Master of Business Studies in Agri-Food Business from Smurfit Graduate School of Business, University College Dublin 1997. During 2002-2003, Thia took sabbatical leave at the University of Southern Queensland, Australia. She completed her PhD in Agricultural Economics at the University of Reading, UK, in 2005.

Thia is currently a member of the National Consultative Committee on Common Agricultural Policy. She was previously appointed an Expert Evaluator for the EU Commission's Seventh Framework Programme in 2010 and 2011. For four years, 2008 to 2012, Thia was a Director of Animal Health Ireland.

In 2012, Thia was awarded the title of Outstanding Young Researcher by the British Agricultural Economics Society.

Stan Lalor and Dr Padraig French (Teagasc); John Bryan (Outgoing IFA President); Dr Jane Brogan (EPA); Thomas Ryan (Executive Secretary of IFA Environment and Rural Affairs Committee); and Dr Tommy Boland (UCD).

Smart farming

Stan Lalor (Teagasc, Crops Environment and Land Use Research Programme, Johnstown Castle) and Dr Padraig French (Teagasc, Animal & Grassland Research and Innovation Programme, Moorepark) contributed to a successful seminar held by the IFA in Portlaoise on November 4.

The seminar focused on improving farm returns through better resource management. The seminar highlighted the cost savings that can be made by improving soil fertility and grassland management.

Beef, sheep, dairy and tillage farmers, who completed resource studies on their farms, discussed the savings identified.

This seminar is part of a sector-wide initiative called 'smart farming' which focuses on ways to improve returns through better resource management.

Some measures identified as part of this initiative include:

- cattle slurry spread in spring is worth €1.80 more per 1,000 gallons than slurry spread in summer;
- upgrading loft insulation in the family home will save €250 a year;
- Installing a variable speed drive to the vacuum pump makes sense. It can give a 60% reduction in pump running costs;
- each extra day at grass can reduce milk production costs by 0.16c/L and is worth €1.54 per suckler cow per day; and,
- by reducing losses in the pit and at feeding by 7%, you can save €15 per tonne of dry matter fed.

See www.smartfarming.ie for the full guide and all the cost savings identified.

T-Stór now in RIAN

T-Stór, Teagasc Open Access Repository, is now included as a participating repository in RIAN, the national open access portal, which aims to make Irish research material more freely accessible, and to increase the research profiles of researchers and their institutions.

RIAN is a web-based open access portal that now harvests and displays the content from the repositories of 13 Irish research institutions, including the seven universities, the Marine Institute and the HSE. Participation in RIAN is an exciting development as T-Stór was launched only a year ago. RIAN will assist in the wider dissemination of Teagasc's research outputs. It will also provide a Europe-wide platform for Teagasc research, through the forthcoming inclusion of RIAN in the EU's OpenAIRE portal.

For more see www.rian.ie or http://t-stor.teagasc.ie/

Irish lab awards

Dr Paul Cotter's Vision I laboratory at Teagasc Food Research Centre, Moorepark, has won the Food and Agriculture Lab category in the Irish Lab Awards. The Vision I lab focuses on three main areas: antimicrobial peptides with a view to their use as food preservatives, microbial composition of food and the microbial composition of the human gut (with a view to the development of foods that can modulate this microbial composition in a beneficial manner).

Three other Teagasc Labs were shortlisted for awards: The Animal Bioscience Lab in Grange, the Soils and Environment Lab in Johnstown Castle, and the Residue Lab in Ashtown.

Dr Cotter is pictured with Dr Catherine Dempsey, Judging Coordinator.

EU animal production research

Teagasc researchers feature in a new EU publication: *A decade of EU-funded Animal production research*. Projects included in the publication are: 'A whole systems approach to optimise feed efficiency and reduce the ecological footprint of monogastrics'; 'Global cooperation to develop next generation whole genome sequence selection tools for novel traits'; 'Sustainable solutions for small ruminants'; 'Innovative and practical breeding tools for improved dairy products from more robust dairy cattle'; and 'Bright farm by precision livestock farming – animal and farm-centric approach to precision livestock farming in Europe'.

http://ec.europa.eu/research/bioeconomy/pdf/decade_of_eu-funded_animal_production_research_en.pdf

Consumer insights for new product development and marketing opportunities in domestic and UK markets

A new collaborative research project examining consumer insights for New Product Development (NPD) is due to commence in Teagasc Ashtown in conjunction with University College Cork. This research is funded by the Department of Agriculture Food and Marine under the FIRM programme and the aim is to provide extensive and up-to-date consumer insights and market knowledge in response to ever-changing consumer patterns, trends and food preferences and thereby increase likelihood of market success. This will be achieved by exploiting existing consumer databases to:

1) profile new consumer segments; and,

2) to evaluate the drivers of consumer food choice and the impact of trends such as health and sustainability. This research will provide deeper insights into NPD marketing opportunities in both domestic and UK markets.

Over the next two years, a wide-reaching and practical dissemination programme will be undertaken though various national workshops and reports. To this end, any food company with a manufacturing base in Ireland, or retailer that operates within Ireland, is welcome to participate in this research project by putting forward and discussing their needs and requirements with respect to consumer-focused new product development with the research team.

If interested, please contact Sinéad McCarthy at Teagasc Ashtown. Tel: 01 805 9962 or email: sinead.mccarthy@teagasc.ie or Mary McCarthy in UCC. Tel: 021 490 2075 email: m.mccarthy@ucc.ie

IDB expansion to Saudi Arabia

The Irish Dairy Board Cooperative Limited (IDB) recently announced a €20 million investment in Saudi Arabia. The investment includes the acquisition of a 75% interest in Al Wazeen Trading LLC (Al Wazeen) and the development of a new state-of-the-art cheese manufacturing plant at the Al Wazeen facility in Riyadh.
Commenting on the announcement Kevin Lane, CEO, IDB said: "Today's announcement represents a major route to market and value for Irish dairy in the post-quota environment. This investment is strategically very important as it allows us to expand our business throughout the MENA region. With innovation and new product development being critical to growth, our partnership with Teagasc is an excellent example of how, with innovative technologies, we can create new ways of producing and selling dairy products for a global audience."
Professor Paul Ross, Head of the Teagasc Food Research Programme said: "Teagasc is delighted to be collaborating with the Irish Dairy Board in applying the technologies developed in the food research centre in Moorepark, to develop fresh cheese types suitable for markets in the Middle East. The ambition of the collaboration is to continue to develop a pipeline of new innovative products to meet specific consumer and customer needs in key global markets for the Irish Dairy Board. This will contribute to the returns farmers receive for the milk they produce."

Teagasc Milk Quality Conference

The key to continued production of quality milk is to have correct information, make the right decisions and carry out the recommended actions correctly. That was the clear message from a milk-quality conference that took place at the Horse & Jockey Hotel, Co. Tipperary on Wednesday, December 4. Maintenance and improvement in milk quality will be increasingly challenging in the expanding milk production environment post-quota.
Four technical sessions took place during the conference dealing with issues of the food industry, bacterial quality of milk, residues in milk and milk somatic cell count. A panel discussion focused on issues critical to driving of the dairy product industry in Ireland. Furthermore, Bord Bia outlined details of the new quality assurance scheme.
Teagasc researcher Dr Bernadette O'Brien said that the critical prerequisite for the manufacture of quality dairy products is to start with milk of the highest quality. The milk-quality criteria requested by milk processors and by customers are generally becoming more strict and rigorous. It is important that requests to milk producers for improved quality milk be accompanied by the necessary information required to produce such milk, particularly in light of new pressures from expansion of herds and the reality of reduced labour supply.
This milk quality conference is the latest event in an overall strategy to improve milk quality on-farm. It follows a 'Milking Equipment Cleaning Guide', as well as a new series of video clips showing critical stages of milking management through to bulk tank milk storage on both smaller and larger farms. See: http://www.agresearch.teagasc.ie/moorepark/milkquality
This conference brought various, relevant stakeholders together with a view to production of premium-quality milk while maximising profitability for producers and efficiency and markets for processors.
A special issue of the peer reviewed *Irish Journal of Agricultural and Food Research* was prepared for this conference (Volume 52, No 2, 2013) and is available from: http://www.teagasc.ie/research/journal/

Threesis competition

The NUIG Threesis competition challenged participants to present their research in just three minutes, using three slides and to three judges. The presentation had to be understood by everyone, regardless of their background. Sara Vero, a Walsh fellow with Teagasc, Johnstown Castle and NUIG Civil Engineering was awarded second place. Sara's presentation gave a brief overview of her PhD on soil physics, the first year of which has just been completed.

Overseas training for Walsh Fellow PhD

Teagasc Walsh Fellow Sophie Sherriff has succeeded in stretching the boundaries of her PhD project with the Agricultural Catchments Programme by securing funding for intensive research training in Scotland and Australia.

Sophie, based at Johnstown Castle Crops, Environment and Land Use Research Centre, is investigating the sources and dynamics of soil loss in agricultural catchments with Drs Daire Ó hUallacháin and Owen Fenton at Johnstown Castle, Professor John Rowan at University of Dundee, and the ACP team. An exciting element of her work now includes a placement with Dr John Walden at the University of St Andrews in Scotland and Professor Stewart Franks at the University of Tasmania. The Scottish placement is funded by the Teagasc Short-Term Overseas Training Award for Walsh Fellows and will involve sophisticated analysis of soil and sediments from the Irish catchments for magnetic properties. This work will extend a series of geochemical and radionuclide measurements undertaken in the Johnstown and Dundee laboratories that help to determine if certain soils and locations are vulnerable to erosion. However, these 'fingerprints' have to be identified by complex statistical routines and training for this in Tasmania has been funded by an Australian Bicentennial Scholarship, awarded by Kings College, London.

Sophie explained that robust assessment of sediment sources, which integrates multiple, well defined source areas will help to advise on best management strategies to support sustainable intensification. She added: "The opportunity to work with international experts in my research field will improve the understanding of sediment dynamics in Ireland by using the best available measurement and analysis techniques".

Report on consumer acceptance of novel food technologies

How do consumers balance the scales between promised benefits and potential risks from novel food technologies? This was one of the research questions examined by a team of Irish researchers investigating consumer and industry acceptance of novel food technologies (NFTs).

Investment by the Irish Government, as well as the EU, in novel food technologies is essential as such technologies will help in delivering solutions to long-term challenges in society such as climate change and a growing world population. However, lessons learned from GM means that consumer acceptance of such technologies cannot be taken for granted, and needs to be managed through effective engagement. This requires greater understanding of consumers' knowledge, attitudes and behaviour.

A new report on the research undertaken by Teagasc, UCC and the Dublin Institute of Technology was launched at a Teagasc Food Innovation Gateways event in Ashtown, in October. The report identifies the complexities in how consumers form attitudes to NFTs. This complexity is demonstrated by the fact that consumers who accept one technology may not necessarily accept another technology, and even acceptance of one application of a technology does not imply acceptance of another application of the same technology.

Consumers do not accept NFT applications on the basis of promised benefits alone. This research identified how consumers' traded-off benefits (including lower price) for potential perceived risks associated with such technologies. In general consumers were more accepting of novel technology if they perceived the associated personal and societal benefits to outweigh potential risks. Awareness and understanding of many novel technologies (such as nano-technology) is limited and the majority of people are not particularly motivated to assess the pros and cons and th us make evaluation on gut feelings and instinct. Many consumers turn to regulatory authorities, such as the Food Safety Authority of Ireland, and trust that such agencies can ensure that products available on the market are safe.personal control, attitude to nature and technological progress and trust in stakeholders, framed consumers' overall attitudes towards the specific technology."

Clearly there are significant challenges for policy makers, regulatory authorities, researchers, and indeed industry, in effectively engaging with consumers to balance the challenge of using technologies to provide food that is acceptable to consumers, that contributes to solving societal/global issues and provides returns to taxpayers for their investments in research and development.

Horizon 2020 expert advisory groups

The European Commission has appointed the 15 groups of independent experts to advise on priorities for Horizon 2020, the next EU research and innovation programme (see article on p12). While all groups have been appointed, groups are being finalised on an on-going basis as individual experts accept the appointment. Most of the groups can already be found on the European Commission's online register for expert groups, along with some additional information and the original call text: http://ec.europa.eu/research/horizon2020/index_en.cfm?pg=h2020-experts

The call for expressions of interest will stay open for the lifetime of the Horizon 2020 programme in order to accommodate the renewal of groups at the end of each mandate.

Earth observation conference winners

Two Teagasc Walsh Fellows recently won awards for their presentations at the 7th Irish Earth Observation Symposium recently hosted in Ashtown.

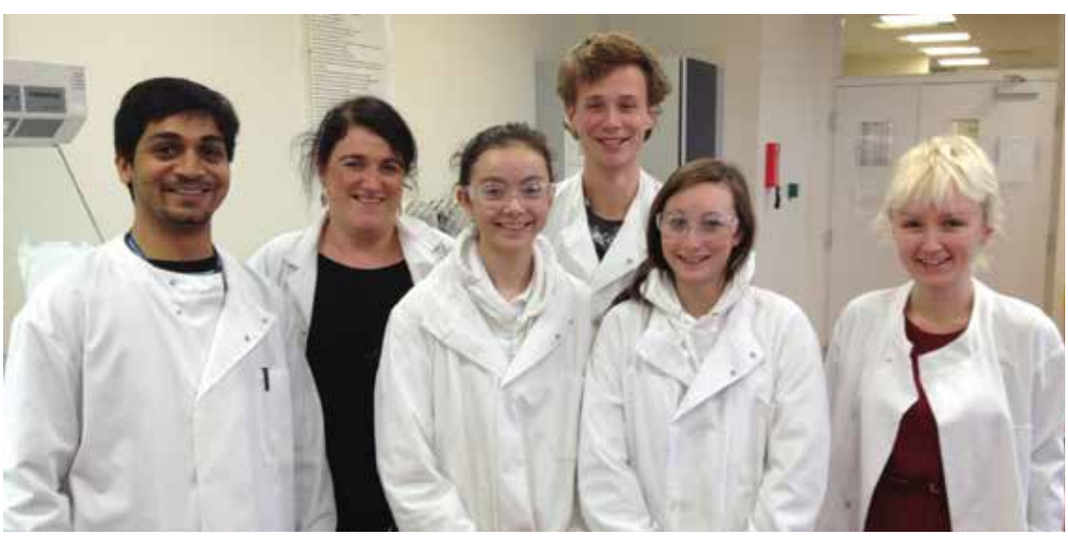
Mick Corcoran won Best Student award for "Expanding landscapes: the application of data from airborne laser scanning to archaeological research and heritage management" (Teagasc and UCD). While, Iftikhar Ali won Best Overall award for "Grassland Yield Estimation based on Satellite Data: A machine learning approach" (Teagasc and UCC).

Launch of agri-food funding

Minister for Agriculture, Food and the Marine Simon Coveney TD has announced awards of over €26 million for agri-food and forestry collaborative research projects being undertaken by researchers from institutions across the island of Ireland. Pictured at the announcement in Fallon & Byrne Food Hall were Dr Aidan Moloney, Teagasc; Minister for Agriculture, Food and the Marine, Simon Coveney, TD; Professor Helen Roche, UCD Conway Institute; and, Minister of State at the Department of Agriculture, Food and the Marine, Tom Hayes, TD. Photo: Fennell Photography.

Voice Box

Dr Paul Galbally, a Research Officer in Teagasc Crops, Environment and Land Use Research Programme recently took to the stage at the VISUAL Centre Carlow to talk about the ANSWER project. Voice Box is a new initiative that aims to provide a platform for vocalising innovation and artistic practice. Ten speakers were given five minutes each to present an aspect of their career that inspires them.



EU Young Scientist

Sophie Healy-Thow and Ciara Judge (front centre), winners of the 2013 National BT Young Scientist and EU Young Scientist competitions who were on placement in the Department of Crop Science, Oak Park in November to experience science in action from Walsh Fellow Dheeraj Rathore (left), Dr Sinead Phelan (second from left) and Walsh Fellows Jeroen Stellingwerf (back) and Aoife O'Driscoll (right).

Ethiopia visit

Teagasc Director, Professor Gerry Boyle recently visited a pilot project entitled 'Developing sustainable seed potato production systems for improved livelihoods', which is being implemented with the Irish NGO Vita in the Chencha region of Ethiopia and is pictured on a recent visit.

This project was set up as part of Teagasc's new policy on international food security; it will empower and strengthen the local knowledge base by funding and training three Ethiopian PhD students.

The world is your oyster

NutraMara, the Marine Functional Foods Research Initiative, recently held a workshop for students and researchers involved in this growing field to present their findings to stakeholders. NutraMara is a programme for marine-based functional food development, which aims to mine marine bioresources including seaweeds (macroalgae), microalgae and marine processing by-products as well as aquaculture, for functional food ingredients that may benefit human health.

Pictured at the event are: Dr Ivan Coulter, Chair NutraMara Board; Dr Fiona Manning, Programme Manager, NutraMara; Dr Phillip Allsopp, University of Ulster; Brid O'Riordan, Glanbia Nutritionals; Sinead Proos, Food for Health Ireland; Ross Campbell, CyberColloids; Declan Troy, Director, NutraMara; Sara McArdle, Enterprise Ireland.

AVTRW meeting

Pictured at the 47th Annual Scientific Meeting of the Irish Branch Association of Veterinary Teaching & Research Work Irish Branch Annual Scientific Meeting 2013 are: Dr Brian Markey (University College Dublin), Professor Gregers Jungersen (Speaker, Danish Technical University), Dr Sam Strain (Animal Health and Welfare Northern Ireland), Maria Guelbenzu MRCVS (Agri-Food and Biosciences Institute, Northern Irealand), Dr Jarlath Nally (University College Dublin) and Dr Kieran Meade (Teagasc).

Eighteen speakers presented research findings covering areas as diverse as bovine post-partum uterine health, leptospirosis, bovine viral diarrhoea (BVD) and emerging viral diseases of pigs. A variety of presentations on mycobacterial diseases - bovine TB and Johne's disease - supported a keynote lecture delivered by Professor Gregers Jungersen (Head of Immunology & Vaccinology at the National Veterinary Institute of the Danish Technical University in Copenhagen) entitled 'Can we use immune-based diagnostics or vaccines to control Johne's disease?'.

Creating global food entrepreneurs

Food Works is a new joint initiative between Teagasc, Bord Bia, and Enterprise Ireland that is designed to support and nurture Irish food entrepreneurs, helping them to bring their food business ideas from concept to market. Food Works seeks out high-innovation potential entrepreneurs who can demonstrate ability to grow the business, export products and create employment. *TResearch* highlights some of the products to emerge from the initial Food Works programme.

Food Works is now almost half way through its second programme. The first programme commenced in 2012 and, from over 100 applications, 25 businesses completed a robust business feasibility, or test phase. From this, 11 successful candidates completed the programme in mid-2013.

Food Works primarily consists of providing premium education and mentoring in the form of marketing advice and assistance from Bord Bia, technical support from Teagasc, and commercial/funding supports from Enterprise Ireland. The development agency input is supplemented by a range of externally sourced, experienced and successful business specialists.

For its part in Food Works, Teagasc provides science-based support to the burgeoning businesses through research and development work; product testing at the Teagasc Food Research Centres in Ashtown, Dublin and Moorepark, Fermoy, Co. Cork; and advice from Teagasc scientists and technologists.

The programme is already seeing the first signs of success as participants from the first Food Works programme have already brought products to market and are delivering on the ambitions of Food Works.

Dairy Concepts IRL

Tom Brennan – together with his brother Ed, and business partner Paul Simpson – is developing an exciting and innovative, all-natural, hand-held cheese snack under the brand 'Fruchee', using a revolutionary new cheese-making technology developed by Teagasc researchers.

'Fruchee', Tom explains, does not taste or smell of cheese but of the flavours children know and love, such as strawberry, peach and raspberry, while having all the nutritional benefits of cheese. Tom says the product satisfies the needs of parents and children and taps into global food trends, such as increased snacking and the quest for healthy foods.

Tom says Food Works is looking for projects that are innovative and have potential to develop on a global scale. He believes Dairy Concepts fits this bill perfectly, and found real benefit in working alongside Teagasc during the programme. "Our project is a unique example of marrying an entrepreneur with a research

IASC's Irish butter with organic shellfish and organic seaweed, which can be used in a variety of recipes, was developed in conjunction with Food Works.

body to commercialise a revolutionary cheese-making technology," he said. "This is disruptive innovation at its best."

Ireland already has a strong dairy industry, which will see milk quotas end in 2015 and, Tom says, innovating in Ireland's dairy industry ties in well with the goals of the Food Harvest 2020 report, the industry-led initiative, supported by Government. The company, incubated at Teagasc Moorepark, is currently finalising its consumer research, working on product prototypes and developing a full-scale manufacturing solution. It expects to go to market in Ireland and the UK in 2014 by partnering with a leading player in the Irish dairy industry and achieve retail sales of stg£20m within three years.

Orpens Cider

While the craft beer category has seen a growth in popularity in recent years, Chris Hill and business partner Matt Tindal saw potential for a similar craft cider market. They entered the Food Works programme with their product, Orpens.

Unlike other products and businesses in the Food Works programme, Orpens cider was already available on the market.

Although the duo had several years' experience in Ireland's wine distribution industry, and both hail from families that had been involved in apple orchards, Chris and Matt worked with Teagasc in developing their product. Chris explains that Orpens worked with Dermot Callaghan in Kildalton Agriculture College, who, he says, was very helpful in introducing the entrepreneurs to apple growers around the country. "We visited orchards with Dermot. That was fascinating and helped us to forge great relationships with some great growers." This, he adds, provided them with good insights into the scale of plantings that exist among the different categories of apple (cider, culinary and dessert) and the different varieties of apple within each category.

Orpens also worked with Karen Hussey, Head of Laboratory, Food Industry Development Department at Teagasc, Ashtown who ran a series of analyses on our different batches of product. "We were trying to standardise our product across a number of quality variables such as alcohol content, sweetness, acidity, weight/body, degree of fizziness (CO_2 content), etc. Orpens also received valuable support from Teagasc in label compliance for both domestic and international markets through Karen Hussey and Ita White.

Orpens has international ambitions and has kick-started an international move by supplying some product to Russia. It intends to also target the UK and US markets. Chris says there is already a good cider market in the UK and that it is growing in the US. Furthermore, he expects Australia to be a growing market in the near future.

IASC Atlantic Seafood Company of Ireland

Similarly, Colin Ross and his business partner James Grimes had previous experience in Ireland's food industry. IASC produces a seafood butter that combines Irish butter with organic shellfish and organic seaweed. Colin says that joining the Food Works programme "challenged but greatly accelerated the business in the right direction". He explains that the company was able to take advantage of Teagasc's Ashtown facilities where it established and still uses a food R&D and incubation unit. Working there several days a week, IASC worked on its production process, exploring issues around food allergens, cross-contamination, sensory analysis and more, with the help of their Teagasc mentor, Pat Daly, Head of Food Industry Development and other food researchers at the Ashtown centre. Furthermore, he says, Teagasc was readily available to help solve any technical queries facing the company in its early developmental stages. Topics of food legislation and food labelling were also discussed with the company's Teagasc mentor.

Colin describes the relationship between Teagasc and IASC as very open and honest, "Teagasc were very good to deal with," he says and adds that, with the help of Pat Daly, the company was able to overcome many initial challenges.

Colin commends Teagasc for having commercial awareness during the process, as well as being a technology support. "We were very lucky to be part of Food Works and lucky to meet someone who was open to the potential of the project."

According to Colin, an important element of the Food Works programme is networking and he adds that, through Teagasc, the company was networking with the right people to solve technology challenges for its processes. Furthermore, he says, having the backing of an agency of an organisation, such as Teagasc, gives credence to the company and its product. "Being rubber stamped by such credible organisations as Teagasc, Enterprise Ireland and Bord Bia, including Bord Bia's Origin Green programme, is important." Colin adds: "Enterprise Ireland is providing us with innovative high potential start-up funding."

While no longer participating in Food Works, IASC continues to benefit from the relationship it has built with the three agencies involved. The company continues to avail of Teagasc facilities and equipments at a cost that has made starting a new business easier.

Máire Geoghegan-Quinn, EU Commissioner for Research, Innovation and Science at the launch of Horizon 2020 in Dublin. Image courtesy of Sharppix.

Opportunity on the Horizon

Teagasc's Research Support Team take a look at the successes of the outgoing European Commission's 7th Framework Programme for Research and Technological Development (FP7) and examine what its successor, Horizon 2020, will have to offer.

Dr Raymond Kelly, Head of Research Support, Teagasc, Head Office, Carlow.
Dr Kim Reilly, Research Support Officer, Teagasc, Ashtown.
Correspondence: Raymond.Kelly@teagasc.ie

Framework Programme 7

The European Commission's (EC) 7th Framework Programme for Research and Technological Development (FP7) ran from 2007 to 2013. With a total budget of more than €50 billion, it was seen as a key tool to respond to Europe's needs in terms of jobs and competitiveness and to maintain leadership of the global economy.

FP7 was organised into specific programmes: cooperation; ideas; people; and capacities (see below). The two main strategic objectives of FP7 were to strengthen the scientific and technological base of European industry and to encourage its international competitiveness, while promoting research that supports EU policies.

FP7 specific programmes

- Cooperation: This programme focused on 10 key thematic areas, including 'Food, agriculture and fisheries, and biotechnology'; and 'Environment (including climate change)'. It accounted for two thirds of the overall budget.
- Ideas (European Research Council): This programme focused on 'frontier' or 'blue-skies' research.
- People (Marie Curie Actions): This programme provided support for researcher mobility and career development.
- Capacities: The overarching theme of this diverse programme was to strengthen the research capacities that Europe needs to become a thriving, knowledge-based economy. It included funding for European research infrastructure and research for the benefit of SMEs.

Ireland as a whole, and agriculture and food research in particular, has benefitted enormously from participation in FP7. In terms of budget, up to July 2013, Ireland had an application success rate of 21.91% (above the EU average) and had secured €572 million of research funding. It is expected that this figure will be more than €600 million by the time all FP7 contracts are signed. The 'food, agriculture and fisheries, and biotechnology' theme has been one of Ireland's most successful in FP7, with 2.24% of the total EU budget coming to Ireland. Teagasc involvement in FP7-funded projects has led to contracts worth almost €12 million and involvement in projects worth a total of €228 million. This multiplier effect emphasises the importance of involvement in European research.

Here, we highlight here a small number of the projects in which Teagasc has been involved:

GrassMargins
Coordinated by Dr Susanne Barth of Teagasc's Crops Research Department, this project aims to enhance biomass production from marginal lands using perennial grasses. The GrassMargins consortium consists of 12 partners from eight European countries, Russia and China and involves three small and medium enterprise (SME) partners.

AUTOGRASSMILK
Funded under the FP7 'Research for the benefit of SME associations' programme, this project aims to develop and implement improved sustainable farming systems that integrate the grazing of dairy cows with automatic milking. Coordinated by Dr Bernadette O'Brien of the Livestock Systems Research Department, this project involves research organisations and SME associations from Ireland and five other European countries.

ICT-AGRI 2
This ERA-NET, which brings together 23 European research funding agencies, aims to coordinate research funding in the area of Information and Communication Technologies (ICT) and robotics for sustainable agriculture. The ERA-NET is led by the Danish Agency for Science Technology and Innovation, and Irish involvement is led by Dr Raymond Kelly and Reamonn Fealy of Teagasc. It builds on the success of the first ICT-AGRI ERA-NET, which has already completed two joint-funding calls and developed a Strategic Research Agenda for this important research area.

Blastohit 2012
This Marie Curie Intra-European Fellowship was written by Drs Pauline Scanlan and Paul Cotter. At the time, Dr Scanlan was a post-doctoral researcher in the Zoology Department at the University of Oxford. She was interested in moving to Ireland to work with Dr Cotter's group in the Teagasc Food Biosciences Department. This is exactly the kind of mobility that is encouraged and funded by the FP7 People programme. Dr Scanlan will complete a two-year project on the role of the single-celled protist *Blastocystis* in human intestinal disease.

FLINT
This project will define farm-level indicators to improve the policy evaluation on (amongst others) cross compliance, sustainability and innovation in the CAP. It is led by Wageningen University and Research Centre (WUR) and involves 11 partners from nine European countries. Teagasc involvement is led by Dr Thia Hennessy of the Agricultural Economics and Farm Surveys Department.

Horizon 2020

Horizon 2020, which will run from 2014 to 2020, succeeds FP7 as the research and innovation funding arm of the EU budget. It is funded as part of the 'smart and inclusive growth' financial framework, which aims to secure Europe's global competitiveness, driving growth and job creation, while addressing citizens' concerns about their livelihoods, safety and the environment. With a budget of almost €80 billion (current prices, adjusted for inflation), Horizon 2020 represents an increase of nearly 30% in real terms compared with FP7. At the recent Irish launch of Horizon 2020, Seán Sherlock Minister for Research & Innovation announced a target of €1.25 billion worth of funding to be secured by Irish participants in the new programme.

Horizon 2020 is structured into these priorities:

- Support for 'Excellent Science' – including grants for individual researchers from the European Research Council and Marie Sklodowska-Curie fellowships.
- Support for 'Industrial Leadership' – including grants for SMEs and indirect finance for companies.
- Support for research to tackle seven 'societal challenges', including 'Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy'; and 'Climate action, environment, resource efficiency and raw materials'

Speaking recently, the European Commissioner for Research, Innovation and Science, Máire Geoghegan-Quinn, stated that "the two most important themes running through Horizon 2020 are simplification and coherence". Simplification will apply across the whole programme. While the different instruments in FP7 have lots of different rules, Horizon 2020 applies the same rules everywhere, meaning that it will be much easier to apply and participate in projects. This should lead to less paperwork and fewer audits. In addition, under Horizon 2020, projects will be up and running in eight months, four months earlier than under FP7.

The entire programme has been redesigned from top to bottom to be much more coherent, providing support at every step of the journey, from excellent fundamental research all the way to innovative products and services.

One of the biggest changes is Horizon 2020's challenge-based approach. According to the Commissioner, "this is because the challenges facing Europe – whether food and energy security, clean transport, public health or security – cannot be solved by a single field of science or technology, let alone a single sector, or a single Member State".

The EC documents will be less prescriptive about what projects need to do. This will allow researchers and innovators to come up with the bright ideas to address the challenges and boost the economy. However, there will be an increased focus on the impacts that projects must have, and this will be one of the key criteria for selecting which proposals get funding.

As well as funding the best science through the European Research Council and the Marie Curie actions, Horizon 2020 aims to facilitate innovation in businesses. Simplification will help to encourage company involvement in Horizon 2020, as will the guiding ethos of support from 'lab to market', which will offer private companies greater scope to get involved in close-to-market actions.

Horizon 2020 welcomed by Teagasc

- The new programme has been warmly welcomed by Teagasc's Director of Research, Dr Frank O'Mara. Speaking after the European Parliament's adoption of Horizon 2020, he said: "Teagasc is looking forward to engaging with our European collaborators over the next seven years to tackle research questions that can only be dealt with at a European level. In particular, the societal challenge of 'food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy', which has been identified in Horizon 2020, is one which is not possible to address on a national basis, it requires the bringing together of expertise and resources from all across Europe."
- Dr O'Mara also emphasised the importance of national research funding schemes saying: "Winning research funding at a European level, is only made possible because of the investment by Irish funders such as the Department of Agriculture, Food and the Marine, Enterprise Ireland, Science Foundation Ireland, the Environmental Protection Agency, the Irish Research Council and others. This investment allows us to build capacity and expertise that we can then use to leverage non-exchequer European funding." Finally, Dr O'Mara highlighted the vital role played by the Irish National Support Network in assisting researchers to engage in FP7 and said that he looks forward to their continued support in Horizon 2020.

Tanzanian Landscape: Tanzania is called the "Africa's sleeping giant" because of its huge unexploited agricultural potential. Add a bit of water to this landscape and you can feed millions of people..

Africa Agriculture Science Week 2013

Dr Lance O'Brien is a member of the International Expert Panel developing 'A Science Agenda for Agriculture in Africa', and was an invited participant at the 6th Africa Agriculture Science Week. He reports here on the event.

Dr Lance O'Brien, Head, Foresight and Strategy Development, Teagasc Head Office, Oak Park, Co Carlow
Correspondence: lance.obrien@teagasc.ie

Every three years, the Forum for Agricultural Research in Africa (FARA) convenes a continental assembly of stakeholders associated with African agricultural development. This gathering has become known as the Africa Agriculture Science Week (AASW).

The 6th AASW, which was held on July 15-20, 2013, in Accra, Ghana, brought together over 1,000 researchers, policy makers and development professionals from all over Africa and from other continents to discuss scientific advances and progress made towards achieving food security in Africa. The conference and exhibitions focused on the theme: "Africa Feeding Africa through Agricultural Science and Innovation".

The AASW aims to:

- increase knowledge of the problems, opportunities and successes in African agricultural research and development;
- create greater awareness of the roles and contributions of different stakeholders and enhanced networking and interaction; and,
- develop greater appreciation among the participants and the public of the important contributions of agricultural research for development in Africa.

Alongside many specific research discussions, key cross-cutting themes that emerged consistently throughout the week were those of sustainable intensification, of creating more opportunities and recognition for youth and women in agriculture and the need to create new forms of income opportunity in rural areas through private-sector engagement in innovation platforms and enterprise.

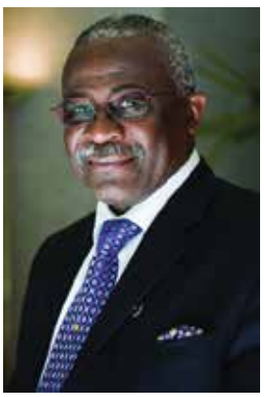
A number of very striking conclusions emerged from the various presentations and discussions:

Development potential

Firstly, African politicians and policymakers are aware that transforming agriculture is not only a precondition for combating food insecurity, but also for unleashing the continent's development potential. The point was made that both upstream and downstream linkages in agriculture are greater than in other sectors and that judicious investment in smallholder agriculture will enable the sector to serve as the engine for national growth and wealth creation.

Agriculture is now viewed by many as the main sector that will enable the continent to consolidate its recent gains on the macro-economic front and to free countless numbers of its people trapped in

Ploughing demonstration, Ethiopia.



Dr Kanayo Nwanze, the President of the International Fund for Agricultural Development (IFAD) and Chair of Science Agenda Expert Panel.

poverty and hunger. Since agriculture is the predominant source of livelihood for the poor smallholder, agriculture-driven growth offers these people the most straightforward means of escaping poverty. According to the World Bank's Development Report for 2008, growth based on agriculture is at least twice as effective in reducing poverty compared to growth generated by other sectors.

This new-found emphasis on the critical role of agriculture in African economic development marks a significant shift from policies of industrialisation and cheap food, which many African countries endeavoured to pursue in the post-colonial period; policies that clearly have not reduced poverty nor created sustainable economic growth.

Investing in the future

Secondly, African leaders appreciate the importance of investing in agricultural research and farm technology so as to lay the foundation for a more productive, competitive and sustainable agriculture that is able to create decent job opportunities for millions of the African citizenry. Furthermore, there is recognition of the importance of investing, not only in research, but also, in agricultural education and extension services. Indeed, the specific objective at continental level is to increase agricultural productivity and competitiveness through the integration of agricultural research, advisory services, education and training.

Taking charge

Thirdly, there was evidence of a growing realisation that science for agriculture in Africa is too important to be outsourced. African leaders must take responsibility for the role of science in society and African countries can, and must, make increased domestic investments in science for agriculture, appropriate to their size and economic status. This conclusion is based on these understandings:

- every country requires sufficient science capacity to participate in the transformation of agriculture;
- each country must determine the most productive directions of its investments in science for agriculture; and,
- the combination of strategy and capacity must be appropriate to the economic size and state of development of the individual country.
- This is a very powerful message that must be taken on board by the thousands of external donors, big and small, who have invested and continue to invest in African agricultural research, and often with very little impact.

These conclusions were emphasised in a very powerful keynote address from Dr Kanayo Nwanze, the President of the International Fund for Agricultural Development (IFAD) and Chair of Science Agenda Expert Panel. His speech advanced strong arguments in favour of the proposition that Africa has both the potential and the will to feed itself and that solution can be found to end food insecurity.

Dr Nwanze argued that researchers and policymakers in Africa must focus their efforts on supporting smallholder farming. A sustainable smallholder agriculture sector will not only feed more people on the continent, but also reduce poverty. Demand exists and is growing, not only for raw, primary produce, but also for higher-value food product. Added to this, many African countries are doing well economically, with GDP growth rates above 5%, new oil finds across the continent, and an abundance of mineral wealth. "So, indeed, Africa does not lack the resources to support agriculture and agricultural research," said Dr Nwanze.

He pleaded for a new approach to research, one that: "repositions research and development so that it is research for development". He said that this means measuring results, not by higher yields alone, but also, by reduced poverty, improved nutrition, cohesive societies and healthy ecosystems. In short, it must be inclusive.

With appropriate policies and investments, he concluded, Africa's "under-performing agricultural system" can bring about food and nutritional security throughout the continent. "Agriculture holds the key to Africa's development, and development holds the key to a future where Africa is not only feeding itself, but feeding the world."

Increasing investment in science

The overall impression gathered from this stimulating event is that African leaders and policymakers realise that now is the time to increase investments in science for agriculture in Africa, when countries have the means and opportunities to invest and secure returns.

Science underpins the solution to many of the dynamic problems Africa is facing – including the sustainable intensification of agriculture – at all scales that is needed to keep food prices competitive in the growing cities. Science makes possible the productivity increases that reduce encroachment of farming onto fragile environments and deals with the growing threats of climate change. Research-based solutions will be needed to support the addition of value-to-agriculture products whose demand is rising through urbanisation and opening of export markets, including expanding of trade within Africa.

Africa is one of the last frontiers of arable land and a new focus for mining of minerals and oil. With proper land management regimes and fiscal management of extractive industries, Africa will have the financial resources for science support and rational management of its agricultural and economic development.

PhD skills

Dr John Finn represents Teagasc on the Management Committee of the Agri-Food Graduate Development Programme. From traditional training sessions to social media, here he outlines what opportunities are available for Teagasc Walsh Fellow students to develop their potential.

Dr John Finn,
Research Officer, Teagasc Crops Environment and Land Use Research Centre, Johnstown Castle, Co. Wexford
Correspondence: john.finn@teagasc.ie

Although the most important training during a doctoral degree is the mentoring and specialised training from a supervisor, some training events and a lot of self-directed learning have always been a feature of doctoral training. Here is an update on some recent and new opportunities that Teagasc Walsh Fellows can avail of. These training events support not just the research being undertaken during the PhD (or MSc), but also address professional development for careers in either industry or research.

Training courses

Teagasc Walsh Fellows are registered with an academic institution, and are jointly supervised by a supervisor from the academic institution and Teagasc. The majority of Walsh Fellows are located at a Teagasc research centre. Thus, the geographical location of Teagasc Walsh Fellows often means that courses at their academic institution are not as available as they might be for someone permanently located on campus. Nevertheless, Walsh Fellows should ensure that they are notified of training opportunities and regularly check the email account of their academic institution.

The Agri-Food Graduate Development Programme (AFGDP) is funded by the Department of Agriculture, Food and the Marine and provides training for postgraduate research students across a wide breadth of topics. The programme aims to provide skills training for postgraduate students in agriculture, agri-environment, forestry, horticulture, food and nutrition. A key feature of the AFGDP is its interaction with industry, and the preparation of postgraduate researchers for careers in industry, as well as academia, underpins the strategic relevance of the programme to the Irish agri-food sector. Topics covered by the programme include: food engineering; food regulation; management and entrepreneurial skills; career development; and several aspects of the agricultural supply chain. Modules in the AFGDP provide experience to students in areas outside of their specific subject and give them an appreciation of activities and developments in the agri-food industry. A significant outcome is the development of inter-disciplinary knowledge of students in preparation for their future careers in the agri-food sector.

The AFGDP training modules are provided in the form of three-day intensive modules that are delivered by national and international experts. The attendance fee is covered by AFGDP, but travelling students need to cover the cost of their travel and accommodation. The modules complement the specific research skills learned as part of a specific postgraduate research project. The AFGDP has been extremely popular with students, and the modules are each worth five credits towards structured doctoral training, which is becoming increasingly prevalent in Irish academic institutions.

As an example of one of the training modules, 'Professional skills for the early-career Agri-Food Researcher' included reflections about career skills and development from leaders in academia and industry. Representatives from national funding agencies spoke about their funding programmes and objectives, and there were presentations on how to apply for and manage EU projects. There was an intensive and interactive session on writing grant proposals, and participants also got the opportunity to learn about intellectual property, and patenting. There were other sessions on research ethics and

Walsh Fellows attending Hugh Kearns' workshop 'The Seven Secrets of Highly Successful Students'. This very effective workshop will be held again on January 29, 2014.

Busy postgraduate researchers at the 'Innovation in the Bio-economy' workshop hosted at UCC by the Agri-Food Graduate Development Programme. Mini-posters were used to define main research objective, and identify specific challenges and concerns. Then, other students and facilitators suggested solutions. This proved a very effective problem-solving technique.

integrity, and a very practical lessons on how to begin leading research teams, and what it means to achieve 'impact' in research.

Teagasc has also initiated a number of training courses for Walsh Fellows. As a highlight, Hugh Kearns (Flinders University, Adelaide, South Australia http://ithinkwell.com.au) delivered a very effective and engaging event for Walsh Fellows last year. Hugh's workshop 'The Seven Secrets of Highly Successful Students' was a combination of taught material, group discussion and self-assessment. Feedback on it was excellent. This workshop will be run again on January 29, 2014.

Online resources

The internet has helped organise communities of researchers in sharing, communicating and coordinating activities and supporting new entrants (such as PhD students) to these communities. Recent years have seen a proliferation of online material to support self-directed learning, including supports for PhD research students. Excellent online resources that address academic writing include http://explorationsofstyle.com/ and http://patthomson.wordpress.com/ and http://doctoralwriting.wordpress.com/ on thesis writing; and on a wider range of relevant topics there is http://www.nextscientist.com/ and http://phdskills.blogspot.ie/

Social media resources

The evolution of social media is also connecting research communities in new ways. Liz Neeley, a keen proponent of science dissemination, recently stated that "being a scientist in 2013 and not having a Twitter account is like being a scientist in 1994 and not having email". At a recent conference, questions during the plenary session were confined to tweets directed to the session chairman, prompting a weary look from many in the audience! Social media also provide several supports for PhD students, and Twitter is a favoured media. All of the main bloggers and traditional online providers alert their followers to new resources via, for example, Twitter and LinkedIn.

Within social media, Twitter chats can provide one of the most innovative and effective supports for PhD students. Twitter chats are coordinated live discussions (by tweet) in which participants respond to questions about a chosen theme (often decided by poll) at a regular time for one hour. There is usually a facilitator, and a range of experience being shared by all the participants. Chats are coordinated by the use of hashtags, and some very effective and popular twitter chats are hosted by #acwri (Academic Writing) and #phdchat. Simply enter the hashtag name in the search facility in Twitter to find the date and topic of their next chat. Previous Twitter chats are catalogued, e.g. many of the previous #acwri chats are available to view at http://drjeremysegrott.weebly.com/

For more information on the range and schedule of modules provided by the Agri-Food Graduate Development Programme, see www.foodpostgrad.ie where postgraduate students can join an email list to be alerted about forthcoming modules.

John Finn tweets on postgrad training @PhdSkills and blogs occasionally at http://phdskills.blogspot.ie/ Guest posts are always welcome!

Testimonials

"I attended both the 'Skills for the Early Career Researcher' and 'Science Writing' courses. The interactive-lecture style really helped with the learning experience and mini group projects on the day were a great way to get to know other attendees. I liked the inclusion of speakers from industry in the programme as it brought a real-world dimension to things. Both of these courses were time well spent for me. I returned to my work energised with a new sense of direction!"

Shane Kennedy, Teagasc Crops, Environment and Land Use Research Programme, Oak Park, Carlow

"I attended the three-day module in 'Professional Skills for the Early-Career Agri-Food Researcher'. For me, personally, the highlights were professional career development, writing grant proposals and applying for grants, funding and preparing budgets, and building a professional network. The first professional career development module really got me to think about and focus on what and where I want my career to go. The applied aspect of the module allowed me to look at what I want from my career in the longer term, map out how I want to achieve those goals and determine if my current skills set is sufficient to reach those goals. I felt this process was invaluable because as an early career research it is easy to go from post-doc to post-doc and not really know what the end goal is."

Heather Lally, UCD Post-doctoral Researcher, (now Assistant Lecturer, GMIT)

Science and technology's role in sustainable intensification

Professor Charles Godfray, University of Oxford, recently delivered the fourth lecture in the Teagasc/RDS lectures series on 'Sustainable Intensification and the Role of Science and Technology in meeting the Food Security Challenge'. Dr Lance O'Brien summarises the main points.

Dr Lance O'Brien,
Head, Foresight and Strategy Development, Teagasc Head Office, Oak Park, Co Carlow
Correspondence: lance.obrien@teagasc.ie

Professor Charles Godfray, University of Oxford, set the context for the fourth Teagasc/RDS lecture by pointing to the widespread agreement that global food production will have to increase substantially in the coming years and decades in order to meet the demand of a growing global population. On the supply side, there is increased competition for land, water, energy and other inputs into food production. Climate change poses challenges to agriculture, particularly in developing countries, and many farming practices damage the environment and are a major source of greenhouse gases.

On the basis of these factors, he argued that the existing food system is not sustainable.Without change, the global food system will continue to degrade the environment and compromise the world's capacity to produce food in the future, as well as contributing to climate change and the destruction of biodiversity.

Sustainable intensification

In light of these consequences, Professor Godfray contended that the additional food needed will have to be produced using a policy known as sustainable intensification. Sustainable intensification does not imply a business-as-usual approach to food production tempered by marginal enhancements in sustainability. Rather, as he argued, it demands radical rethinking of food production to achieve major reductions in adverse environmental impacts. Professor Godfray acknowledged that this policy has attracted criticism in some quarters as being either too narrowly focused on food production or as representing a contradiction in terms. Accordingly, he outlined a broader framework of priority actions within which to view sustainable intensification.

Firstly, sustainable intensification implies the need to increase overall food production. Overall increases in production are essential because no one approach to address food insecurity on its own will address future needs, given the inevitability of policy failures, as well as the time lags in the demand-and-supply dynamics of the food system. Immediate yield increases are needed in many low-income countries; elsewhere, the immediate objective may not necessarily be to increase yields but to develop the potential to respond to future increases in demand.

Secondly, increased production must be met through higher yields because increasing the area of land in agriculture carries major environmental costs. Although suitable land for agriculture exists in certain parts of the world, it comprises, in the main, forests, wetlands, or grasslands. Their conversion would greatly increase greenhouse gas emissions and the loss of biodiversity and important ecosystem services.

Thirdly, all responses must be environmentally sustainable by minimising the use of fertilizers and pesticides and generating lower emissions of greenhouse gases. At the same time, they must result in the production of a variety of valued public goods, such as clean water, carbon sequestration, flood protection and landscape amenity value.

Supply-side actions alone will not resolve the challenge of future food needs. On the demand side, actions are needed to reduce population growth rates and to curb high levels of per-capita consumption, particularly for resource-intensive foods. The food system also needs to become more efficient by improving governance and reducing food losses and waste throughout the food chain. No one of these actions on its own is able to achieve sustainability and security in the food system. Sustainable intensification should, therefore, be seen not as a substitute for, but as a complement to, these other necessary measures.

Role of science and technology

Sustainable intensification is not defined in terms of any specific technologies or farming practices. The

Professor Charles Godfray, University of Oxford, delivers the fourth lecture in the Teagasc/RDS lectures on Sustainable Intensification and the Role of Science and Technology in meeting the Food Security Challenge.

most important goal is that if a technology results in efficient food production without adverse ecological consequences, then it is likely to contribute to the system's sustainability. Sustainable agricultural systems make the best of both crop varieties and livestock breeds and their agro-ecological and agronomic management.

Much can be done with existing knowledge. The application of existing knowledge and technology has very substantial potential to increase crop yields, particularly in those countries characterised by significant yield gaps. Above all, there is a need to ensure that existing information and technologies are transmitted to farmers through the operation of efficient and effective extension services.

Biological science, especially publicly-funded science, will have a vital role in ensuring the sustainable intensification of food production. Research to improve the production efficiency and profitability in crop and livestock farming is of key importance. Field-level, eco-physiological research on various crops and livestock is urgently required in anticipation of the possible impacts of global warming and climate change. New crop varieties and animal breeds capable of producing high yields under extreme climatic conditions must be developed.

Significant increases in productivity and sustainability can be achieved by targeted research in modern crop and animal management, often known as agro-ecology. Research into better management is as important as research into plant and animal genetics. The long-established disciplines of agronomy, soil science and animal husbandry need to be revitalised in order to address the challenge of integrating sustainability into agricultural systems much more explicitly.

New science and technology are also needed to raise the limits of sustainable production and address new threats. Professor Godfray argued that there is an urgent need to reverse the long-term decline in investment in agricultural science with a view to:

- producing more food efficiently and sustainably;
- securing ecosystem services;
- keeping pace with evolving threats such as the emergence of new and more virulent pests and diseases;
- addressing new challenges, such as the development of new varieties of crops that are resistant to increased drought, flooding and salinity arising from climate change; and,
- meeting the particular needs of the world's poorest communities.

In this regard, he also mentioned some more revolutionary advances, such as the development of perennial grain crops, the introduction of nitrogen fixation into non-legume crops, and re-engineering the photosynthetic pathways of different plants.

In conclusion, Professor Godfray stated that the world will need a multifaceted research portfolio that helps build capacity in modern biotechnology and other platform technologies, but also strengthens capacity in traditional crop and animal sciences and technologies, as well as embracing traditional local technologies. Evidence from a wide range of studies indicates that no single approach is capable of delivering sustainable, resilient, high levels of productivity, and value. A broad perspective that encompasses the whole food system is needed and a careful blend of approaches will therefore be required. This should include biotechnology, but also areas of science such as agronomy and agro-ecology that have received less investment in recent years. Moreover, these will need to be accompanied by radically new agendas aimed at reducing resource-intensive consumption and food waste and improving governance, efficiency and resilience of the food system.

This lecture is available to view on the TeagascMedia YouTube channel: http://www.youtube.com/playlist?list=PLdcRN-ArFOFhllzybJyDodSiEnuuejW4j

Professor Charles Godfray is Hope Professor of Zoology at Jesus College, Oxford and Director of Oxford Martin Programme on the Future of Food. He is a population biologist with broad interests in the environmental sciences and has published in fundamental and applied areas of ecology, evolution and epidemiology.

Lecture five in the Teagasc/RDS series will be held on Thursday March 27, 2014 and will be given by Dr Maximo Torero, Division Director of the Markets, Trade, and Institutions Division at the International Food Policy Research Institute (IFPRI), Washington, DC.





Extending shelf-life of bread

Chitosan – a by-product of shellfish – and its potential for the prevention of rope spoilage in bread and subsequent bread shelf-life extension.

Dr Maria Hayes, Research Officer, Food BioSciences Department, Ashtown, Dublin 15
Tomas Lafarga, Leonardo Da Vinci student, Food BioSciences Department, Ashtown, Dublin 15
Dr Eimear Gallagher, Senior Research Officer, Food Chemistry Department, Ashtown, Dublin 15
Desmond Walsh, Research Technologist **and Dr Juan Valverde**, Research Officer, Food Biosciences Department, Ashtown, Dublin 15
Correspondence: maria.hayes@teagasc.ie

The total bakery goods market in Ireland is estimated to be worth just over €0.5 billion at the retail level annually, of which 41% is imported (EuroMonitor, 2012). Spoilage by microbes is one of the major factors limiting the shelf-life of bakery products and spoilage from microbial growth causes economic loss for both bakeries and the consumer. Microbiological spoilage by bacteria, yeast and moulds are a concern in high-moisture products such as bread. Bread emerges from the baking process with a surface that is essentially sterile but post-bake handling can quickly lead to microbial surface contamination. Pathogenic bacteria, belonging to the taxonomic class Bacilli, are of importance in the bakery industry as they are thought to cause rope spoilage of baked goods (Pepe *et al*., 2003). Ropiness is a defect in bread and other food products, usually caused by the growth of bacteria such as *Bacillus cereus*, which causes increased viscosity and stringiness of bread and which renders bread and other bakery goods inedible.

In the EU, approximately 750,000 tonnes of crustacean shell is landed as 'waste' every year (Shellfish News, 2012). This waste should really be considered as a valuable by-product as it contains the polymer chitin. Second only to cellulose, chitin is the most abundant biopolymer on earth. It is a linear, insoluble, homo-polymer consisting of β-1, 4-linked N-acetylglucosamine (NAG) units and is the primary protective and structural polymer found in the shell of crustaceans, insects and some fungi, including Basidiomycete mushrooms. Chitosan is a de-acetylated form of chitin. Chitosan is biocompatible, biodegradable, and non-toxic and has known antimicrobial properties (Walsh et al., 2013).

Our work looked at the antimicrobial effect of replacing 1% of bread ingredients with chitosan and assessment of this new bread product against the rope spoilage pathogen B. cereus and bread spoilage moulds.

Chitosan generation

Chitosan was generated from prawn (*Nephrops norvegicus*) by-product consisting of shell and protein material using the method outlined in Figure 2. Prawn shell was de-mineralised and de-proteinated into chitin and then converted into chitosan using strong base material.

Bread-making

Bread loaves were produced following a straight dough baking procedure.
The doughs were prepared for mixing according to the formulations listed in Table 1.

Ingredient	White bread (g)	Chitosan bread (g)
Flour	180.0	178.2
Chitosan	0.0	1.8
Salt	1.8	1.8
Fat	1.8	1.8
Yeast	2.7	2.7
Improver	0.9	0.9
Water	111.4	111.4

Table 1. Composition of bread made using 1% chitosan.

Antimicrobial analysis of chitosan bread

The antimicrobial effect of chitosan addition to bread was studied by assessing the variation in natural mould growth and intentional rope development on both the control and chitosan-containing bread. *B. cereus* strain NCTC 7464 was inoculated into 25mL Nutrient Broth (NB), (Oxoid Ltd., UK) and incubated at 37°C for 24h. The overnight culture was serially diluted in Nutrient Broth (NB) to give the required numbers of c.10^6cfu/mL in the solution used for inoculation of the bread. Cell numbers were confirmed by plating.

Three slices (10mm thickness) of the control and the chitosan-containing bread were cut into 6cm diameter circles and placed into sterile Petri dishes. For both breads, one slice was inoculated with a 1mL aliquot of the diluted *B. cereus* solution, while two slices were set up as controls and inoculated with either 1mL sterile nutrient broth or left un-inoculated. All Petri dishes were placed in plastic bags and incubated at 30°C for

Figure 1. Shell waste material.

72h. Visible mould growth and rope formation was graded as either: none; questionable; slight rope; moderate rope; or significant rope (Figure 3).

Results and conclusions

The addition of chitosan to bread with a molecular weight of 124,000 ± 10,000g/moL and which was 19% de-acetylated was found to inhibit *B. cereus* growth and rope formation in bread when monitored over a three- to five-day period. Natural mould growth was also significantly delayed.

According to the results obtained in this study, substituting 1% of flour for chitosan produced no significant variation in moisture content between the chitosan-containing bread and the control. Chitosan-containing bread and the control had a similar texture profile. When directly inoculated with *B. cereus*, chitosan bread strongly inhibited the growth of *B. cereus* and subsequent rope formation in bread over a three-day period. Control bread samples developed a typical, high-fruity odour after only 24 hours of incubation. Chitosan could potentially be used as an alternative to chemical preservatives to extend the shelf life of bakery products.

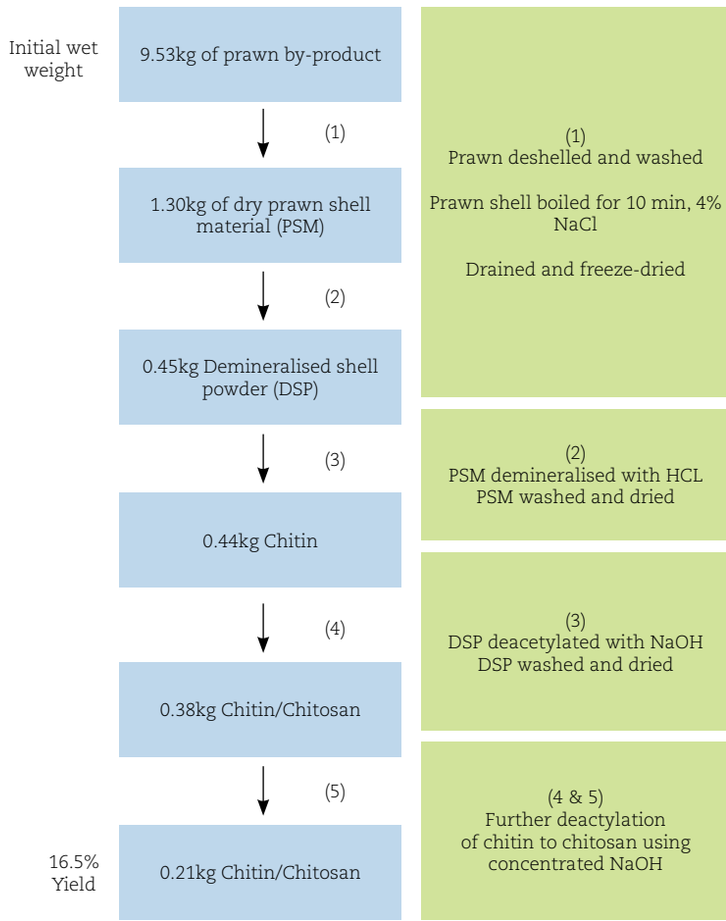


Figure 2. Generation of chitosan from prawn shell waste material.

Figure 3. Inhibition of ***Bacillus cereus*** and mould by chitosan-containing bread.

Acknowledgements

The authors would like to acknowledge the Leonardo da Vinci Programme (2012-2013) for funding to carry out this work. The full article was published recently in the *Journal of Agriculture and Food Chemistry* (see reference).

References

EuroMonitor International Country Report. (2012) 'Baked Goods in Ireland', December 2012, pages 56-57.

Lafarga, T., Gallagher, E., Walsh, D., Valverde, J. and Hayes, M., (2013) 'Chitosan-containing bread made using marine shellfisheries by-products: Functional, bioactive and Quality assessment of the end product'. *Journal of Agriculture and Food Chemistry*, 61: 8790-8796.

Pepe, O., Blaiotta, G., Moschetti, G., Greco, T. and Villani, F. (2003) 'Rope producing strains of Bacillus spp. from wheat bread and strategy for their control by lactic acid bacteria' *Applied and Environmental Microbiology*, 69: 2321-2329.

Shellfish News (2012) 'Crustacean shells as a raw material for chemicals', Spring/Summer 2012, page 4.

Walsh, A.M., Sweeney, T., Bahar, B., O'Doherty, J.V. (2013) Multi-functional roles of Chitosan as a potential protective agent against obesity, 8: 53828-53835.

Reshaping the human body using whey proteins

We may all want to have a body that we could be proud of but, unfortunately, achieving that ideal weight and shape is not an easy task. This article provides a brief insight in to how mammals regulate their weight with the view to addressing the question of why we gain weight so easily. Some ongoing research into how intake of milk-derived whey proteins could prevent weight gain and reshape our body is explored.

Dr Kanishka Nilaweera
Senior Research Officer,
Teagasc Food Research Centre Moorepark,
Fermoy Co. Cork
Correspondence:
kanishka.nilaweera@teagasc.ie

Mammals are able to regulate body weight

Body weight is determined by our food (energy) intake and energy expenditure, which includes physical activity. When our energy intake exceeds energy expenditure, as may occur just after a meal, the excess energy becomes stored as fat in the adipose tissue. If the resulting positive energy balance is sustained by continuous food intake, the storage of fat expands the adipose tissue and causes weight gain. In contrast, when energy expenditure exceeds energy intake, as may occur during increased physical activity, the resulting energy deficit is met by mobilisation of stored fat. This is why long-term physical activity depletes adipose tissue-associated fat, causing it to shrink and lose weight.

It is now known that our body is able to sense energy availability and deficit in order to prevent the above-mentioned extreme alterations to energy balance. During intake of a meal, the gastro-intestinal (GI)-associated mechanisms sense nutrient availability in the GI lumen, which is relayed to the brain. The resulting activation of mechanisms in the brain reduces further intake of the meal, so that the balance between energy intake and energy expenditure could be reached to maintain weight (Figure panel A). The absence of nutrients in the intestinal lumen, as may occur between meals, causes a parallel decrease in the signalling to the brain, which gradually allows another meal to be ingested. In this way, mammals are able to consume meals periodically, with humans generally having meals three times a day. We now know the identity of many of these signals. These include hormones generated from the GI-tract and adipose tissue, as well as neurotransmitters located in the brain that mediate the actions of the hormones. In addition, there is growing evidence that the bacteria (microbes) inhabiting our GI-tract also act to control our body weight (Figure panel A).

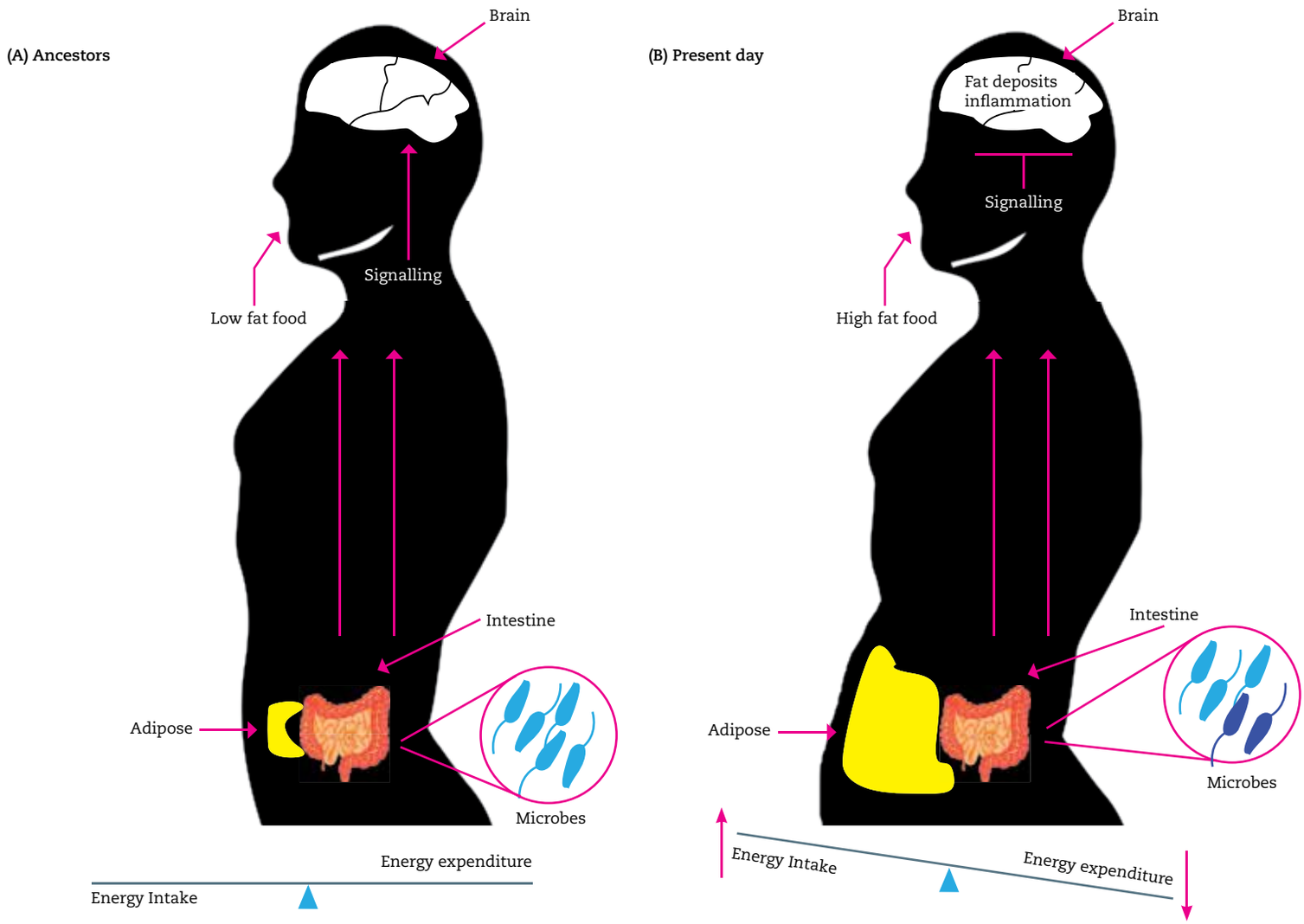
Why do we put on weight so easily?

To answer this question, it is important to highlight the lifestyle choices we have made and now enjoy compared to our ancestors, such as those from the hunter-gather era. Then, humans had limited food, much of it of low-calorific value, which had to be gathered through extreme physical hardship. In this scenario, one could imagine that the energy consumed may have been just sufficient or may even be below the energy requirements of the body. As depicted in drawings from this era, it is likely that our ancestors were leaner in appearance (Figure panel A). From then to now, while the body-weight regulatory mechanisms have largely remained unchanged in the absence of an evolutionary pressure, the availability and calorific value of food have increased in parallel, with decreased physical activity, the latter, in part, due to advances in technology and a more sedentary lifestyle.

It is now known that intake of high-fat diets reduces the brain sensitivity to GI and adipose tissue-derived signals, thus limiting their capacity to regulate energy balance (Figure panel B). The resulting positive energy balance causes deposition of fat in the adipose tissue up to the limit of its capacity, after which, the fat becomes stored in other tissues, including the brain. This causes tissue inflammation, which impedes the action of the above-mentioned signals, leading to a gradual body-weight gain and alteration in body shape.

Could whey proteins reshape our body?

Whey is derived from milk serum, which remains after precipitation of casein during the production of cheese or casein. Whey contains a number of proteins, which are rich in amino acids that could be used as building blocks for muscle. It is therefore reasonable to assume that intake of whey proteins



could alter body shape and weight in a beneficial manner. Indeed, in a recent article published in the *British Journal of Nutrition*, we provided evidence supporting this hypothesis, as we found that mice fed a high-fat diet with whey protein isolate (WPI) gained less weight and had reduced fat mass than mice fed a high-fat diet with casein for a two-month period (McAllan *et al.* 2013). We further found that mice on WPI had reduced lipid and inflammation-related biomarkers in a brain region called the hypothalamus. If fat is not being deposited in the adipose tissue and in the brain, where does it go? The answer to this question may lie in the finding that mice on WPI diet had increased lean mass. As deposition of lean mass is an energy-demanding process, we proposed that the ingested fat, rather than being stored in the adipose tissue, is being redirected to meet the energy demands of the muscle, thereby reshaping the body towards a leaner appearance.

Ongoing work

Research is being performed to assess the long-term impact of WPI on body shape and weight; whether the bioactivity associated with WPI could be narrowed to one or more whey proteins, so that WPI-enriched proteins, with enhance bioactivity, could be created; and, whether the microbial growth-related properties of WPI-derived peptides could be exploited to reprogramme the composition of gut microbiota associated with obesity to one that could provide beneficial effects to the host. The above work is performed in collaboration with Professor John Cryan (UCC); Professor Helen Roche (UCD); Professor Riitta Korpela (University of Helsinki); Dr Paul Cotter (Teagasc); and Professor Gerald Fizgerald (UCC). The postgraduate students involved are Liam McAllan; Bettina McManus; and Peter Skuse.

Relevance to industry

Nutrients that could provide benefits beyond basic nutrition are termed 'Functional Foods'. The current research shows that whey proteins could reshape our body to a leaner appearance. Our ongoing work may help to further identify more bioactive whey proteins and their mechanisms of action, which could be exploited to combat the obesity epidemic worldwide.

This work is supported by the Teagasc Core Funding and by the Teagasc Walsh Fellowship programme.

Reference

McAllan, L., Keane, D., Schellekens, H., Roche, H.M., Korpela, R., Cryan, J.F. and Nilaweera, K.N. (2013). Whey protein isolate counteracts the effects of a high-fat diet on energy intake and hypothalamic and adipose tissue expression of energy balance-related genes. *British Journal of Nutrition* 110: 2114-2126.

Genetic merit for fertility affects uterine health

Stephen Moore and Dr Stephen Butler provide an update on a study of the Moorepark high/low fertility herd, examining the physiology of dairy cows with divergent genetic merit for fertility traits during the transition period.

Stephen Moore, Teagasc Walsh Fellow and **Dr Stephen Butler**, Research Officer in Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark. Correspondence: stephen.butler@teagasc.ie

Establishment of Moorepark high/low fertility herd

For several decades, genetic selection programmes focussed primarily on milk production traits. This was extraordinarily successful, resulting in more than a doubling of average milk production per cow. Unfortunately, genetic merit for fertility traits deteriorated during the period when genetic selection programmes focused heavily on milk-production traits.

In 2007, a study was initiated at Moorepark to investigate the specific effects of genetic merit for fertility traits on reproduction in lactating dairy cows. Heifers due to calve for the first time in spring 2008 with similar genetic merit for milk production, but either good (Fert+) or poor (Fert-) genetic merit for fertility traits were identified from within the national herd in collaboration with the Irish Cattle Breeding Federation. These animals were representative of the top 25% of the national herd in genetic merit for milk production. The Fert+ and Fert- groups represented the top 20% and bottom 5% of the national herd in genetic merit for calving interval, respectively. Heifers that passed the Moorepark Biosecurity protocol were purchased and brought to Moorepark. By standardising genetic merit for milk production, proportion of North American Holstein ancestry and environment (management, nutrition, health protocols), the effect of genetic merit for fertility traits on factors that affect fertility could be investigated.

Initially, a study was undertaken to monitor the milk production and reproductive performance of Fert+ and Fert- cows. Animals were managed as one herd in accordance with the Moorepark blueprint for pasture-based milk production. During their first and second lactations, mean milk solids production tended to be greater in Fert+ cows compared with the Fert- cows (436kg vs. 424kg). During the breeding season, Fert- cows had poorer submission rates (72% vs. 83%), poorer conception rate to first service (33% vs. 56%), required more services per pregnancy (2.2 vs. 1.4) and, as a result, required 28 days longer to become pregnant compared with Fert+ cows. Results from the study indicated that a robust model for investigating the causes of poor fertility had been established (Cummins et al., 2012).

Physiology of cows during the transition period

In spring 2012, a study was undertaken to monitor the physiology of Fert+ and Fert- cows during the transition period. The transition period is defined as the period from three weeks before calving to three weeks after calving. This is a critical time for the health and productivity of dairy cows. In late pregnancy, there is a modest increase in nutrient requirements to support the foetus. After calving, there is a much greater increase in nutrient requirements to support mammary milk synthesis. Cows that fail to adapt to the increased nutrient demands at this time have lower milk production, greater body condition loss and are more susceptible to metabolic disease (milk fever, fatty liver, ketosis), and subsequently have poorer reproductive performance.

Before calving, dry matter intake (DMI) was similar between Fert+ and Fert- cows; but, after calving, Fert+ cows had greater DMI (19.7kg vs. 16.8kg DM/day) during the first five weeks than Fert- cows (17% difference). Average energy balance (energy consumed minus energy required) before calving (mean 5.9 UFL/day) and after calving (mean 0.9 UFL/day) was similar, except for week one after calving when energy balance was greater in Fert+ cows (2.3 vs. -1.1 UFL/day). Fert+ cows had greater daily milk solids production (1.89kg vs. 1.74kg/day) and tended to have greater daily milk yield (24.2kg vs. 22.3kg/day) than Fert- cows. The greater milk production recorded for the Fert+ cows was achieved while they also maintained greater BCS (body condition score) (2.98 vs. 2.75 units) than Fert- cows. Calving BCS was similar for both genotypes, but Fert- cows subsequently experienced greater BCS loss than Fert+ cows (-0.48 vs. -0.35 units).

Studies have shown a positive association between metabolites and metabolic hormones and dairy cow fertility. Circulating insulin (3.25 vs. 2.62 µIU/mL) and insulin-like growth factor-I (102.62 vs. 56.85 ng/mL) concentrations were greater in Fert+ cows than

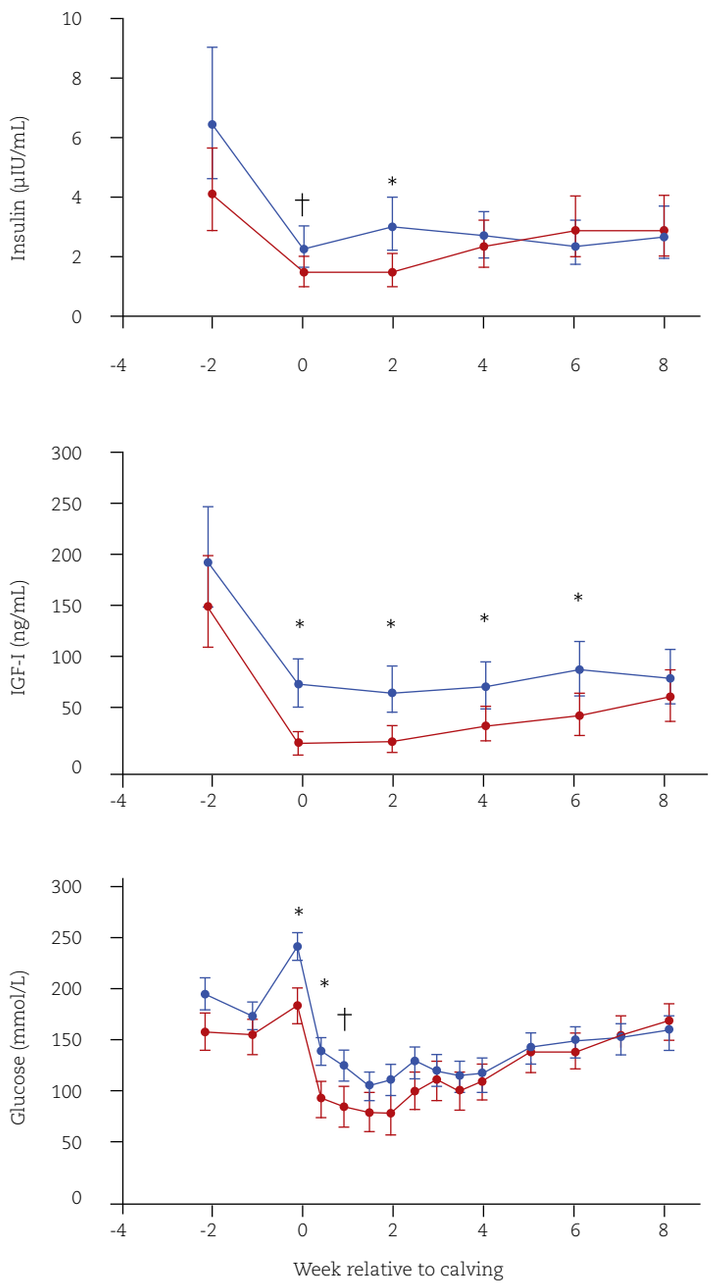


Figure 1. Metabolic status of Fert+ (Blue) and Fert- (Red) cows from week -2 to 8 relative to calving. * P ≤ 0.05, † P ≤ 0.1.

in Fert- cows from two weeks before to eight weeks after calving. Circulating glucose (3.40 vs. 3.01 mmol/L) concentrations were greater in Fert+ cows compared with Fert- cows from two weeks before to three weeks after calving (Figure 1).

Uterine health was assessed by scoring vaginal mucus samples weekly, which is reflective of the level of bacterial contamination, and by conducting a cytology exam of the cells within the uterus to determine the proportion of immune cells. A high proportion of immune cells indicate an ongoing uterine infection. Vaginal mucus scores during weeks two to six after calving were lower in Fert+ cows than in Fert- cows. Based on uterine cytology, a smaller proportion of Fert+ cows were classified as having endometritis at weeks three (0.42 vs. 0.78) and six (0.25 vs. 0.75) than Fert- cows. The differences in uterine health between genotypes is likely due to differences in their immune status, which would be improved in Fert+ cows compared with Fert- cows due to their more favourable metabolic status (Ingvartsen and Moyes, 2013).

Milk progesterone analysis indicated that a greater proportion of Fert+ cows had resumed cyclicity by six weeks after calving (0.86 vs. 0.20) compared with Fert- cows. Superior uterine health and earlier resumption of cyclicity may be mediated through differences in DMI, energy balance, metabolic status and body condition score profiles. Importantly, phenotypic improvement in fertility traits was achieved without antagonising milk production.

Benefits to industry

Improvements to fertility traits were achieved without antagonising milk production. Cows with a high EBI fertility sub-index have a faster recovery from uterine infection and resume ovarian cyclicity earlier after calving. As a result, the need for veterinary intervention can be reduced and fertility improved by selecting sires with a high fertility sub-index to generate replacement heifers with superior genetics for fertility traits. In addition, improved reproductive performance will facilitate better synchronisation between pasture supply and demand and earlier calving will increase the proportion of cows that complete a full lactation, thereby increasing milk production from pasture.

The National Development Plan and the Dairy Levy Trust funded this research.

References

Cummins, S.B., Lonergan, P., Evans, A.C.O., Berry, D.P., Evans, R.D. and Butler, S.T. 2012. Genetic merit for fertility traits in Holstein cows: I. Production characteristics and reproductive efficiency in a pasture-based system. *Journal of Dairy Science* 95: 1310-1322.

Ingvartsen, K.L. and Moyes, K. 2013. Nutrition, immune function and health of dairy cattle. *Animal 7* (Supplement s1): 112-122.

Animal breeding using DNA technologies

Researchers from Teagasc, ICBF and Weatherbys have developed a customised, low-cost DNA-chip to increase genetic gain for profit in dairy and beef cattle.

Dr Michael P. Mullen, Research Officer and **Dr Sinéad M. Waters,** Senior Research Officer, Teagasc, Animal and Bioscience Research Department, Animal & Grassland Research and Innovation Centre, Grange, Dunsany, Co. Meath
Dr Matthew C. McClure, Dr Francis Kearney and Dr Andrew Cromie, Geneticists, ICBF, Bandon, Co. Cork
Dr Rebecca Weld and Dr Paul Flynn, Senior Medical Scientists, Weatherbys, Kildare, Co. Dublin
Dr Donagh P. Berry, Principal Research Officer at Teagasc, Animal and Bioscience Research Department, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork.
Correspondence: michael.mullen@teagasc.ie

Teagasc, in collaboration with the Irish Cattle Breeding Federation (ICBF) and Weatherbys Ireland, has developed a custom DNA-chip called the International Dairy and Beef – or IDB – for dairy and beef cattle breeding. This genotyping platform provides, at a low cost to the producer, several types of useful DNA information to aid cattle breeding. The custom array facilitates the generation of accurate genomic selection proofs, as well as providing an extremely accurate tool for parentage verification and assignment. The array eliminates the requirement for multiple testing (and associated costs) by also incorporating the diagnostic tests to screen for lethal genetic defects, congenital disorders and known major genes (e.g., myostatin for double muscling). In addition to being a market leader in price and information content, the IDB also provides improvements over existing approaches. More importantly, its content is dynamic and, because it was developed in Ireland, will always be optimised for Irish dairy and beef producers.

Background

Teagasc research, in collaboration with the ICBF, led to the development and implementation of genomic selection for Irish dairy cattle in 2009 (Berry *et al.*, 2009). Ireland was the second country in the world to do so. Genomic selection exploits information on the DNA of individual animals to more accurately predict their genetic merit. Even prior to 2009, DNA technologies were used in parentage testing and testing for some genetic mutations (e.g., complex vertebral malformation (CVM), bovine leukocyte adhesion deficiency (BLAD), deficiency of uridine monophosphate synthase (DUMPS)). However, this meant hair sampling animals, multiple times, and undertaking separate DNA tests, all incurring their own individual costs. In 2012, Teagasc, the ICBF, and Weatherbys decided to collaborate to develop a DNA-based array that had sufficient information for genomic selection, yet also contained the necessary information for more accurate parentage testing and the ability to screen for genetic mutations of interest to industry. The motivation for such an endeavour was cost reduction, but also to remove the inconvenience of multiple sampling.

IDB array content

The base information used on the IDB is internationally used for dairy genomic evaluations. Our improvements to this international standard were three-fold (see below). This platform also provided an opportunity to evaluate and refine on-going DNA-based Teagasc research.

Improved accuracy of genomic evaluations

To reduce the cost of genotyping, many countries genotype animals with fewer DNA markers on low-density SNP panels and then, by implementing sophisticated mathematical algorithms, impute (i.e., predict) markers found on higher density, and more expensive, panels (Berry *et al.*, 2013). The more single nucleotide polymorphisms (SNP) on the low-density panel the greater the accuracy of imputing to higher densities and, therefore, the greater the accuracy of subsequent genomic evaluations. We added 5,500 additional DNA markers to the international standard, for a marginal cost, but with a considerable

improvement in the precision of the genomic evaluations through better prediction of the higher density genotypes of an individual, especially in beef cattle.

Parentage verification and assignment

Parentage testing changed from being based on blood-typing to DNA microsatellite technology in the 1990s. Because blood typing and DNA microsatellites are different technologies, all back-pedigree animals had to be genotyped for the DNA microsatellites. Genomic selection uses a different type of DNA marker called SNPs. SNPs are lower cost and, therefore, more SNP markers can be measured on an individual, making it more accurate than microsatellites for parentage verification. Moreover, SNP genotypes can effectively be used for parentage assignment where the sire is unknown but his SNP profile is in the ICBF database. Transitioning from microsatellites to SNPs, however, implies that all back-pedigree would have to be re-assessed on the SNP technology. The IDB incorporates an approach developed to generate a cross-tabulation between SNPs and microsatellites, thereby eliminating the requirement and cost for all back-pedigree to be reassessed for SNPs (McClure *et al.*, 2013).

Lethal mutations, congenital defects and major genes

Most performance traits are governed by several thousand DNA variations. However, a select number, such as double muscling and polled (i.e., no horns), are governed by one or only a few DNA variants. Moreover, if two copies of the same DNA variants exist in an embryo the pregnancy may fail; examples of such mutations include CVM, BLAD and DUMPS, which are routinely tested for in sires used for artificial insemination. We included DNA variants from 53 major genes on the IDB array. Fifteen of these tests are royalty bearing and incur an additional fee if their information is requested.

Research

A total of 1,873 DNA variants selected, which are part of ongoing research in Teagasc into the role of mutations in the genes of the somatotrophic axis on performance in cattle (Mullen *et al.* 2011, 2012a,b), were included in the array. Because all genotyped animals eventually have performance records, this platform facilitates the testing of ongoing research into the genomic architecture of animal performance.

IDB genotyping in Ireland – progress to date

Since its release in March this year, 13,849 Irish dairy and beef cattle have been genotyped using the IDB. Genomic evaluations for the dairy animals have been based on the results from the IDB array; genomic selection for beef cattle is still underway and requires a larger population of beef animals with DNA information. To date, 5,406 animals have been parentage-verified using the IDB. With microsatellite genotyping costs at €20 per animal, this equates to savings of over €100,000 so far this year for Irish breeders.

Carriers of known lethal recessive conditions, brachyspina and CVM have been detected in the Irish Holstein-Friesian population at 2% and 4% prevalence, respectively. In addition, congenital disorders citrullinaemia, osteopetrosis and syndactyly were identified at low frequencies (<1%). Functional variants in the myostatin gene (nt821, F94L and Q204X) exist in Irish Angus, Belgian Blue, Charolais, Limousin and Simmental populations (Mullen *et al.*, 2013).

IDBv2

The IDB is under continual development with a planned re-evaluation annually. Version 1 of the IDB, which was released in March 2013, facilitated the screening of 53 major genes. Version 2 of the IDB, scheduled for release in January 2014, will have the capability to screen for 102 major genes. Additional DNA markers have also been included on IDBv2 to assign cattle breed and also improve the precision of genomic selection proofs even further.

The IDB – designed for both beef and dairy cattle – is superior to the commercially-available low-density panel, as it increases the accuracy of genomic evaluations, enables parentage testing, screens for mutations relevant to the cattle industry (such as lethal recessive mutations, genetic defects and major genes), as well as providing an avenue to generate genotype information on mutations of research interest.

Acknowledgments

Breed societies, AI stations Paul VanRadan (USDA) and Jon Beever (Illinois University). Financial support from the Irish Department of Agriculture, Food and the Marine through the Research Stimulus Fund (RSF-06-353; 11/S/112; 11/S/104) is acknowledged.

References

Berry, D.P., McClure, M.C, Mullen, M.P. 2014. Within and across-breed imputation of high density genotypes in dairy and beef cattle from medium and low density genotypes. *Journal of Animal Breeding and Genetics* (in press).

McClure, M.C. *et al.* 2013. Imputation of microsatellite alleles from dense SNP genotypes for parentage verification across multiple *Bos taurus* and *Bos indicus breeds*. *Frontiers in Genetics* doi:10.3389/fgene.2013.00176.

Mullen, M.P. *et al.* 2011. Single nucleotide polymorphisms in the insulin-like growth factor 1 gene are associated with performance in Holstein-Friesian Dairy Cattle. *Frontiers in Genetics* 2: 3.

Mullen, M.P. *et al.* 2012a. Polymorphism discovery and allele frequency estimation using high-throughput DNA sequencing of target-enriched pooled DNA samples. *BMC Genomics* 13: 16.

Mullen, M.P. *et al.* 2012b. Characterization of genetic variation within the somatotrophic axis in DNA pools of beef and dairy cattle divergent for milk production, size, fertility and immune response. *Journal of Animal Science* 90 (Supplement 3): LB2i.

Mullen, M.P. *et al.* 2013. Development of a custom SNP chip for dairy and beef cattle breeding, parentage and research. *Interbull Bulletin* No. 47.

Bacterial causes of clinical mastitis

A recent study reveals the complex bacterial causes of clinical mastitis in Ireland and will help develop effective mastitis control strategies.

Dr Orla M. Keane, Research Scientist, Animal & Grassland Research and Innovation Centre, Teagasc, Grange, Dunsany, Co. Meath. **Finola McCoy MVB**, Programme Manager, CellCheck, Animal Health Ireland, Carrick-on-Shannon, Co. Leitrim. Correspondence: orla.keane@teagasc.ie

Intramammary infection (IMI), or mastitis, is estimated to be the most costly disease to the dairy industry in Ireland. A recent survey of dairy industry stakeholders by Animal Health Ireland (AHI) identified udder health/milk quality as a priority area for improvement. This was instrumental in the establishment of the CellCheck programme, the AHI-led initiative to improve udder health and reduce the somatic cell count (SCC) of the national herd. A variety of bacterial species are implicated in causing mastitis and species are classically referred to as contagious or environmental pathogens, depending on how they behave within dairy herds. Contagious pathogens, such as *Staphylococcus aureus* and *Streptococcus agalactiae* generally spread from cow-to-cow, with the infected udder being the primary source of the pathogen. Environmental pathogens, which include coliform bacteria, such as *Escherichia coli*, and *Streptococcus uberis* are found in the environment where the cow lives, and spread directly from there to the udder. However, it is more recently recognised that many environmental mastitis pathogen species also contain strains of bacteria that occur in many herds, suggesting that these strains may be capable of cow-to-cow contagious transmission. Therefore the classical definition of mastitis pathogens as contagious or environmental is not absolute.

Current protocols for mastitis control include hygienic milking and housing conditions, routine milking machine maintenance, post-milking teat disinfection, dry cow therapy, isolation of infected animals and cow culling. Some control strategies target cow-to-cow transmission of bacteria, while other strategies reduce the risk of infection from bacteria with an environmental source. In order to evaluate current control strategies and devise required modifications, the local on-farm bacterial challenges must be identified and quantified but there is a dearth of information on the aetiology of clinical mastitis on Irish farms.

Pathogens causing mastitis

A study carried out over 30 years ago on autumn calving cows, profiled the pathogens then associated with both sub-clinical and clinical mastitis at drying-off on farms in Ireland. The contagious pathogens *S. aureus* and *S. agalactiae* were identified as the predominant mastitis-causing pathogens responsible for over 60% of mastitis cases. In order to generate up-to-date information on the aetiology of clinical mastitis in Ireland we profiled the bacterial pathogens currently responsible for clinical mastitis in 30 milk-recording dairy herds in Ireland over a 12-month period. Samples were collected from any cow in lactation that presented with clinical mastitis over the entire lactation period, from 27 commercial and three research herds. The mean annual bulk tank somatic cell count (BTSCC) of the herds involved in the study was 224,515 cells/ml and ranged from 103,630 cells/ml to 302,147 cells/ml. Spring, split spring/autumn and autumn-calving herds were included in the study. Clinical mastitis was diagnosed based on the usual criteria (clots, flecks or blood in the milk or heat or swelling in the udder) and milk samples were taken aseptically from the affected udder quarter before antibiotic treatment commenced. In total, 630 samples were available for analysis. In order to identify the pathogen causing intramammary infection, standard laboratory methods recommended by the National Mastitis Council (1999) were used. The bacteriological profiling results are presented in Figure 1. *S. aureus* was recovered from 22% of samples, *S. uberis* from 17% of samples, *E. coli* from 9% of samples, while *Streptococcus dysgalactiae* and coagulase-negative Staphylococci (CNS) accounted for 5% and 4% of samples respectively. No pathogen was identified in 42% of samples due to lack of bacterial growth in culture or sample contamination.

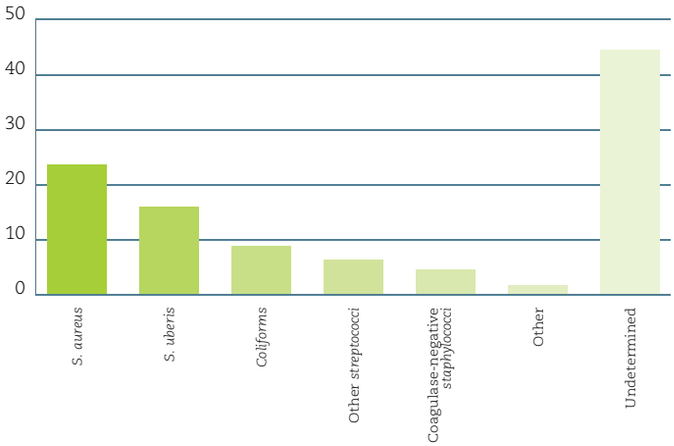


Figure 1. Bacteriological profiling of clinical mastitis in Ireland.

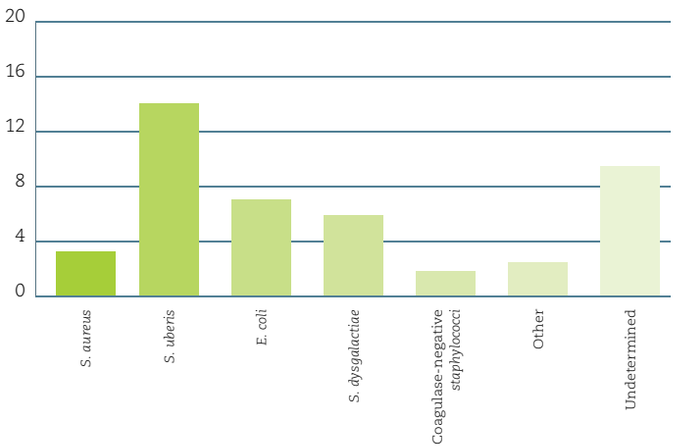


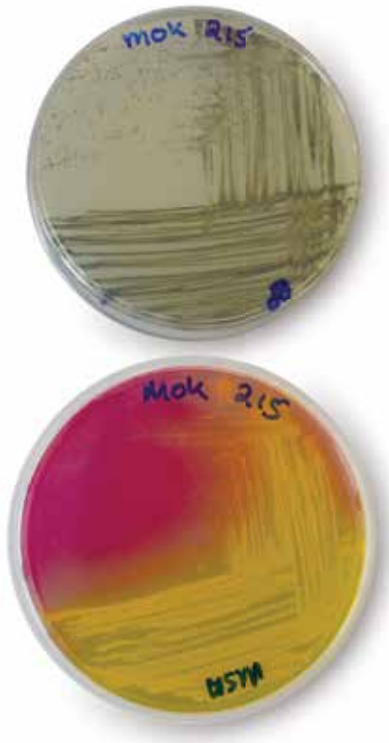
Figure 2. Mastitis pathogen DNA detected by RT-PCR in culture-negative samples.

Detecting mastitis-causing bacterial DNA

As no live bacteria were recovered from a large proportion of samples, we used Real-Time Polymerase Chain Reaction (RT-PCR) to detect DNA from mastitis causing bacteria in 43 culture-negative milk samples. Mastitis pathogen DNA could be detected in 34 of the samples by RT-PCR. The most common pathogen detected in the culture negative samples was *S. uberis*, which was detected in 14 samples. *S. aureus* DNA was found in only three samples. This was an interesting finding, as traditionally culture negative samples from cows with clinical mastitis symptoms, or an elevated SCC, have often been interpreted as an indicator of *S. aureus* infection, not detected with culture due to intermittent bacterial shedding. However, we found that undetected *S. aureus* infections were rare and culture-positive milk samples were significantly more likely to indicate the presence of *S. aureus* than culture-negative PCR-positive samples. The pathogens detected by RT-PCR in culture negative samples are shown in Figure 2.

Mastitis control strategy

In order to develop effective mastitis control strategies, the on-farm bacterial challenges must be identified and quantified. Yet, the last study to examine pathogens associated with clinical mastitis in Ireland dates to the early 1980s. There have been substantial changes in dairy farming practices, mastitis awareness and control and the



mean BTSCC since then. Traditionally mastitis prevention and control measures targeted those pathogens considered to have contagious transmission patterns. Such programmes can lead to a reduction in the prevalence of these pathogens but can result in a shift in the relative pathogen frequency to environmental pathogens. In this study, *S. aureus* was found to be the most common pathogen in culture-positive samples followed closely by *S. uberis*, although no bacteria were isolated from a large number of samples. The frequency of contagious pathogen isolation was substantially less than in the early 1980s but was in line with a recent study on the aetiology of sub-clinical mastitis. The environmental pathogen *S. uberis* was the second most commonly isolated pathogen overall. The frequency of *S. uberis* isolation is in marked contrast to the early 1980s when *S. uberis*, accounted for only 2-3% of mastitis pathogens. In the early 1980s, a sizable *S. agalactiae* challenge existed, however, in this study only a single *S. agalactiae* isolate was found indicating that the prevalence of this pathogen has declined. The pathogen profile reported here agrees quite closely with recent data on the aetiology of sub-clinical mastitis indicating that similar pathogens are causing clinical and sub-clinical mastitis. Bacterial DNA was identified in a number of samples from which no live bacteria could be isolated and *S. uberis* was the species most commonly detected by this method. However, the presence of bacterial DNA does not confirm the presence of live bacteria required to cause infection, and so the clinical significance of these results requires careful interpretation.

In conclusion, *S. aureus* remains the bacterium most commonly associated with mastitis in these Irish milk-recording herds, although other pathogens, particularly the environmental pathogens *S. uberis* and *E. coli* also present a considerable challenge that should not be ignored. Ireland has recently launched a national udder health programme, CellCheck, which has established best practice, and is building industry capacity to manage both contagious and environmental mastitis challenges. The findings from this study indicate the importance of such a holistic approach. For more on the CellCheck programme see: www.animalhealthireland.ie

Reference

National Mastitis Council. (1999) Diagnostic procedures. In: "Laboratory Handbook on Bovine Mastitis". National Mastitis Council Inc., Wisconsin, USA pages 31-39.

Dr Sinéad McCarthy, Research Officer, Food Market & Consumer Research Group, Department of Agrifood Business & Spatial Analysis
Dr Paul Naughton, University of Newcastle (former Walsh Fellow and Research Officer in Agrifood Business & Spatial Analysis)
Dr Mary McCarthy, Senior Lecturer, Department of Food Business & Development, University College Cork
Correspondence: sinead.mccarthy@teagasc.ie

Avoiding your way to healthy eating behaviour

Teagasc and University College Cork (UCC) researchers recently finalised a study on the factors that prevent healthy eating intentions in Irish adults.

To engage in good dietary practice, consumers require both knowledge and motivation; however, even though most consumers understand the meaning of healthy eating and are motivated to behave in a healthy manner, general food consumption practices in Ireland do not comply with dietary guidelines. In this respect there appears to be a 'motivation-to-intention' gap that represents a barrier to healthy eating behaviours. Indeed, this weak relationship between motivation and intentions around healthy eating has been a point of study for many researchers.

Research was undertaken by Teagasc, Food Market & Consumer Research Group at Ashtown and UCC on this topic, the aim of which was to identify and quantify the importance of factors that prevent enactment of healthy-eating intentions within an Irish population.

An extensive literature review, in conjunction with in-depth consumer interviews, identified six key factors that were frequently associated with successful/unsuccessful behavioural change. These are: dietary goal; action control; perceived need; self-control; habit; and hedonic hunger. Those who are successful in enacting healthy eating behaviours tend to:

- have identified an important target outcome (dietary goal);
- believe that they need to change their behaviour for a particular reason, such as health or body weight (perceived need);
- plan and monitor all relevant behaviours necessary to attain their dietary goal (action control); and,
- believe they possess control over their food choices and eating behaviour (self-control).

Furthermore, successful enactment of healthy-eating behaviours could be impaired due to the consumption of certain foods occurring frequently and at an unconscious level (habit) and experiencing strong motivation to consume as a result of merely thinking, seeing and/or tasting the food (hedonic hunger).

Survey of Irish adults

Five hundred Irish adult consumers were surveyed to determine the extent to which each of the aforementioned factors influenced dietary avoidance behaviours. Avoidance of sugar and confectionary

products formed the basis of the enquiry.

All six factors were associated with the quantities of sugar consumed. Stronger perceived need (to reduce sugar consumption), and sense of control (action and self-control) were associated with lower daily intake of sugar, while a stronger perceived habit and feelings of hedonic hunger were closely related to higher daily consumption of sugar. The most significant influence on behaviour was habit followed by perceived need.

These findings were further strengthened by comparing intenders who had successfully reduced their sugar consumption in the previous six months to those who had failed to do so. Successful intenders had a dietary goal and also demonstrated strong self-control. Those who had a dietary goal were seven times more likely to successfully reduce sugar consumption compared to those without a specific goal. Similarly, compared to those with low levels of self-control, intenders with a high level of self-control were three times more likely to be successful at reducing their sugar consumption.

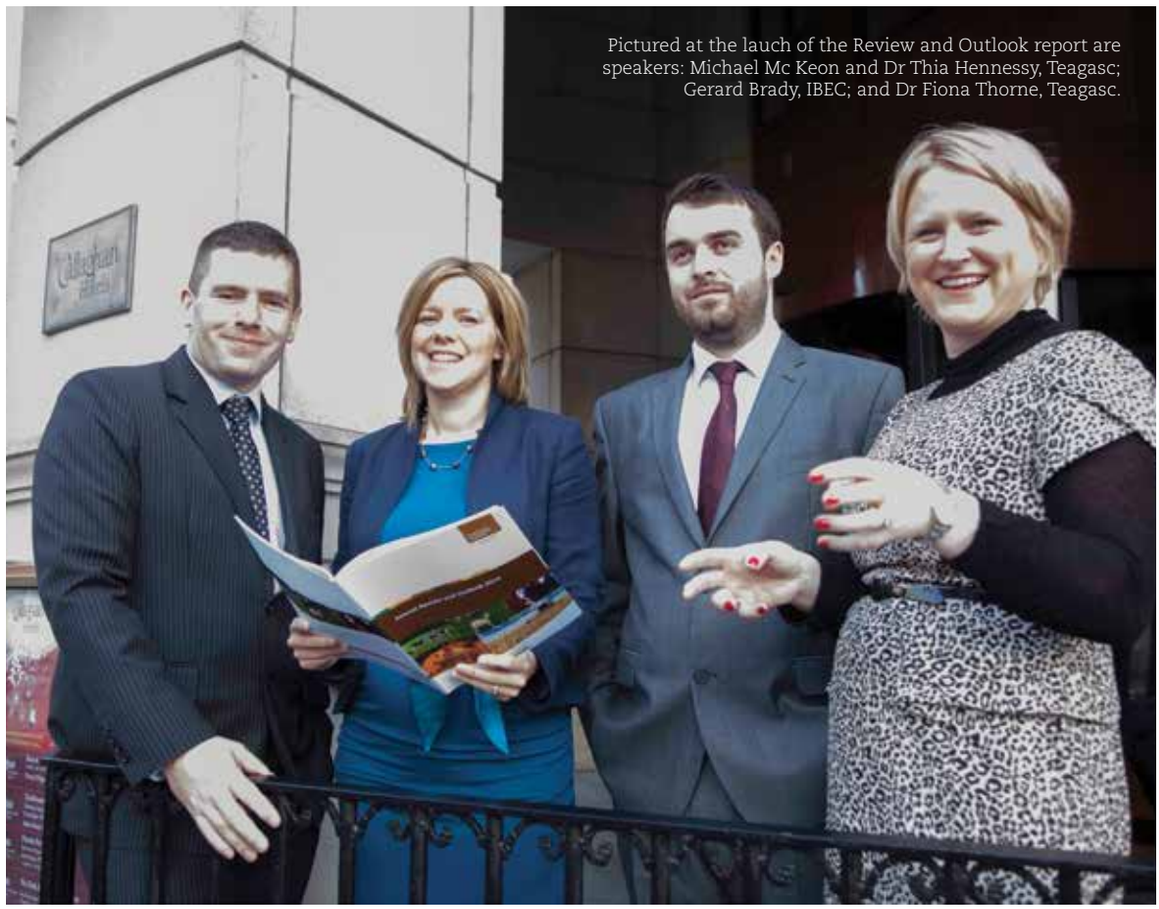
Dietary behaviour change

This research confirms the importance of self-regulation, control, habit, dietary goals, perceived need and hedonic hunger in successful dietary behaviour change. There is considerable theoretical support for the proposition that enhancing self-regulation skills is one of the most important ways of achieving a healthier diet. Hence, any measures that can address these factors and support self-regulation can have implications for both public health policy and new product development.

From a public health policy perspective, goal setting, as well as goal monitoring, should be encouraged and facilitated. It is important to promote goals that are related to behaviour rather than physiological targets. For example, a long-term abstract goal 'to feel healthier' influences a medium-term goal to lower cholesterol, which influences a shorter-term goal to lose a few lbs/kilos in weight by eating less high-calorie foods. Thus, defining interim goals that allow for 'little successes' on a regular basis should enhance commitment to the new behaviour.

Enabling better behaviour

People should also be encouraged and facilitated to self-monitor dietary behaviour related to short- and medium-term goals, which are easier to evaluate. There is an opportunity for industry to be innovative with food packaging that can support consumer self-monitoring; and develop augmented product features, such as internet and phone application dietary planners that can help people to control portions sizes and track their food intake and calories consumed.



Pictured at the lauch of the Review and Outlook report are speakers: Michael Mc Keon and Dr Thia Hennessy, Teagasc; Gerard Brady, IBEC; and Dr Fiona Thorne, Teagasc.

Review and outlook

Economists from the Teagasc Agricultural Economics and Farm Surveys Department presented a review of farm incomes in 2013 and a forecast for 2014 in their annual conference in December. The following article summarises the developments on agricultural markets and in farm income in 2013 and provides forecasts for 2014.

Trevor Donnellan,
Dr Kevin Hanrahan,
Dr Thia Hennessy
Dr Fiona Thorne
Economists, Agricultural Economics and Farm Surveys Department, Rural Economy Development Programme, Teagasc
Correspondence: thia.hennessy@teagasc.ie

2013 - weather conditions drive input expenditure

The review of 2013 concluded that the recent fodder crisis, which ran from the autumn of 2012 to the spring of 2013, was likely to have cost the farming sector over €400 million across the two financial years, comprising approximately €380 million of additional feed expenditure and over €70 million in lost output value. However, rising output prices for some agricultural commodities were sufficient to offset the considerable increases in input expenditure in 2013. This means that income will have increased for some farm systems in 2013, even though incomes for the agricultural sector as a whole were relatively unchanged on the 2012 level.

Following a sharp rise in feed use on dairy and drystock farms in 2012, feed use increased further in 2013, due to the depletion of fodder stocks brought on by poor weather in the summer of 2012. This problem was compounded by the late arrival of good grass growing conditions in 2013, due to the abnormally cold spring period. Animal feed prices were also higher in 2013. Higher volumes of feed used and high prices led to record levels of expenditure on feed on many farms. See Figure 1 for estimated levels of feed use per head for dairy and beef animals in 2013 and a forecast for 2014.

2013 - a mixed year for income

The negative impact of the considerable increase in the Livestock Feed Bill was alleviated for dairy farms by very strong international dairy commodity prices in 2013. Due to drought in New Zealand and strong demand on world dairy markets, Irish dairy farmers

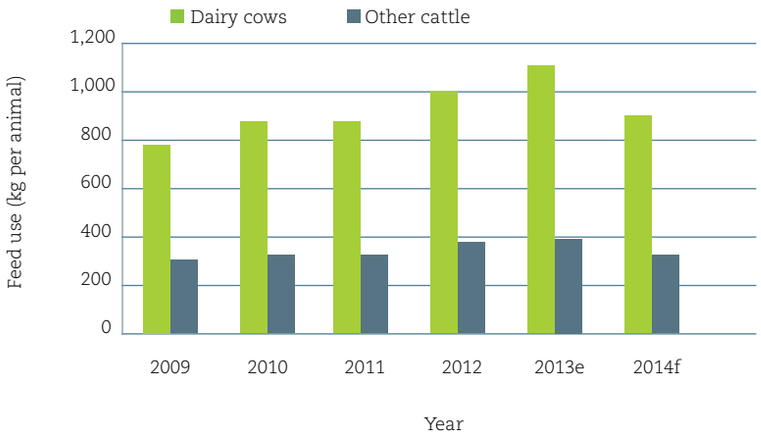


Figure 1. Author's estimates derived from Department of Agricultre, Food and the Marine and Central Statistics Office data. Note: e = estimate.

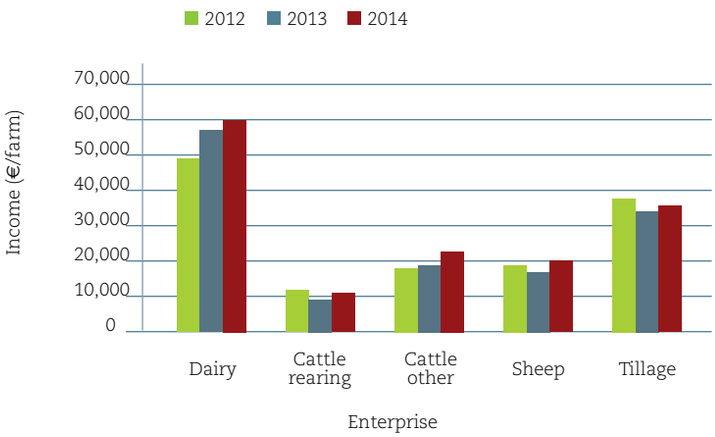


Figure 2. 2012 data from Teagasc National Farm Survey, 2013 estimate and 2014 forecast. Note: e = estimate.

saw spectacular increases in milk prices in 2013, with elevated prices persisting through the peak-production months. An average farm-gate milk price of 38 cent per litre is estimated and this high-price level ensured that Irish milk production recovered in 2013 from the weather-related dip experienced in 2012. On balance, the rise in milk prices was more than sufficient to offset the increase in dairy production costs and consequently Irish dairy farm margins increased in 2013.

However, 2013 was a mixed year for the drystock sector. Profit margins for beef calf producers fell due to both the rise in production costs in 2013 and the fall in calf and weanling prices associated with poor demand for young animals in the spring of 2013. Cattle farmers specialising in fattening and bringing animals for finish fared better as they benefited from an increase in finished animal prices. However, the benefits of this price rise in terms of margins earned were partially offset by higher production costs in 2013.

Cereal production conditions in Ireland were quite good in 2013 leading to above-average yields for the main cereal crops. However, 2013 cereal prices were well down on the 2012 levels due to an improved global harvest, which eased concern about cereal availability globally. In spite of the large increase in yields, the relatively depressed cereal prices, coupled with increased production costs, means that income on cereal farms is likely to have fallen slightly this year.

Taking account of the mixed outcomes across the various Irish farm systems in 2013, overall average family farm income is estimated to have increased by just 1% in 2013 to a sector average of approximately €25,500.

Easing of production costs in 2014

Assuming a return to more normal weather patterns in the spring, input expenditure is expected to decrease for all farm systems in 2014.

An improved global cereal harvest in 2013 has already led to a fall in cereal prices and this is gradually being transmitted to the prices farmers will pay for feed in the coming months. More importantly, a return to normal weather conditions in 2014 should see a 20% drop in the level of feed use on dairy, beef and sheep farms, with usage levels returning to normal for the first time since 2011. Grassland fertilizer use, which spiked in 2013 in response to the fodder crisis, should also return to more normal levels in 2014. In addition, prices for fertilizer in 2014 should be 10-15% lower than the average prices in 2013. With oil prices projected to be lower in 2014, there may also be a slight reduction in farm diesel prices next year.

The outlook for farm income in 2014

These changes in feed, fertilizer and fuel prices should bring about a dramatic drop in input expenditure in 2014, the first major decrease in production costs since the commodities price boom began back in 2007.

On the output side, greater availability of dairy products on the international market should see Irish milk prices drop in 2014 from the exceptional levels being achieved at present. This should be offset by the fall in production costs, leaving income from dairy farming little changed in 2014 in comparison with the 2013 level.

Current expectations are that Irish cereal prices for the 2014 harvest will be similar to those of 2013. However, this forecast remains highly contingent on favourable global production conditions in 2014, as global cereal stocks continue to remain low. Irish cereal yields are likely to be down in 2014, given that they were well above average in 2013. On balance, lower production costs could allow margins to improve but that outcome is contingent on yield levels and, if these revert to a normal level, cereal margins in 2014 should be relatively unchanged on the 2013 level.

The forecast for relatively modest growth in prices for cattle and sheep and this, coupled with a decline in production costs on livestock farms, should lead to an increase in profit margins relative to 2013. The fall in input costs should also generate greater demand for young animals, which should benefit margins earned by for suckler producers in particular.

In general, farm incomes are forecast to improve for all farm systems in 2014 (see Figure 2), and taking the sector as a whole, average family farm income is forecast to increase by about 12% in 2014 to an average of about €28,500.

Monitoring grass from space

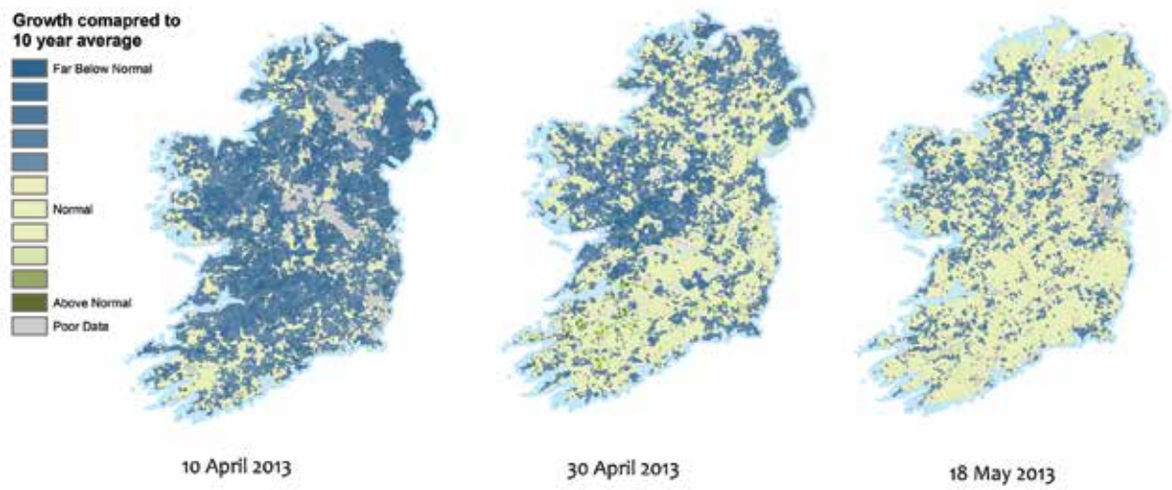


Figure 1. A series of vegetation anomaly maps showing the exceptionally poor growth of vegetation in Ireland (blue colours) in spring 2013. Even by the end of April only part of the country is back to normal (green).

Stuart Green, Research Officer, Agri-business and Spatial Analysis, Rural Environment Development Programme, Teagasc, Ashtown
Iftikhar Ali, Walsh Fellow, Teagasc Ashtown and University College Cork
Dr Fiona Cawkwell, Department of Geography, University College Cork
Correspondence: stuart.green@teagasc.ie

Teagasc and UCC researchers are using satellite imaging to observe and predict grass growth rates.

The Spatial Analysis laboratory in Teagasc, with partners in the Department of Geography, UCC, is developing new tools to estimate grass growth in Ireland using satellite imaging. Along with colleagues in the Grass programme, the aim is to be able, in a short number of years, to give very local measurements of growth rates and, more importantly, predictions for growth over the coming few days or even weeks.

Here we show some current work that allows us to produce maps on a weekly basis that show how grass growth at the scale of townlands can be compared to the 10-year average for that period. This comparison is conveyed in simple language, allowing us to show national and regional variations in production in terms of the local calendar.

Satellite imaging is increasingly familiar through online mapping tools like Google Earth. However, the satellites used in this project have a wider application than just simple imaging. The NASA Aqua and Terra satellites each carry a version of the Moderate Resolution Imaging Spectroradiometer (MODIS). This imaging system captures information, not just in natural colour as a conventional camera does, but in a wide range of energies that tell us different things about the earth below. For the purposes of monitoring grass levels, MODIS can capture images in the Near Infra Red (NIR). This is light that is just beyond the red wavelengths of visible light that we can see, and is important because it is strongly reflected by plants; so in the NIR plants are three or four times brighter than the green and up to 10 times brighter than the red. This bright signal is directly related to the amount of plant material and how well it is growing.

Satellite imagery

Satellites Terra and Aqua are orbiting at an altitude of 705km, and a single MODIS image encompasses all of Great Britain and Ireland, with each pixel of the image representing an area on the ground of 250m x 250m. Thus, the pixel values represent the sum total of light reflected from each 250m x 250m square. We can take the amount of NIR light in each pixel and divide by the corresponding red value to create a vegetation index (VI), a single number in each pixel that represents the amount of living green vegetation in that pixel. The value ranges from -1, no vegetation at all (e.g., desert) to 1 for completely covered by

lush, vigorously-growing vegetation. Using maps of this VI we can compare the performance of each pixel with past performance.

The Terra and Aqua satellites pass over Ireland once a day, around midday. As parts of the country are often covered by cloud, we don't use daily data, but take the data over a week to get the best-quality pixel value, free of cloud. VI maps for that week are created as the data is acquired.

To look at how performance this year compares with the average, a 10-year rolling archive of weekly satellite data has been created. Vigorous quality checks of the data were applied, and only pixels with reliable data were used in the analysis. This allowed us to create a 10-year average performance map for the whole country every week of the year. To compare performance this year with the average we used a concept known as anomaly mapping. As seasons naturally vary, year on year, deviations from the average are only noteworthy if they are exceptionally, or anomalously, large. Anomalous differences are calculated by subtracting the current observation from the 10-year mean and dividing the value by the standard deviation of the 10- year mean. This means that values around zero are 'normal', whereas positive values are anomalously high and negative values are anomalously low.

With this technique, we have been able to track grass growth over the spring of 2013, as the fodder crisis unfolded. The series of maps in Figure 1 show how late the spring growth was and, also, how there is strong regional variation across the country. These maps were made available on a trial basis to some Teagasc advisors on the Teagasc Intranet map web viewer, to give an overview of the crisis. However, following discussions with those advisors it became clear that the information needed to be refigured for a wider farm audience.

Calendar trend mapping

Research has shown that information needs to be refigured into a common language to be utilised fully. When discussing the effect of weather on farming, talk revolves around 'slow growth' or 'spring is late' or 'we're two weeks behind'. Therefore, the decision was made to re-present the maps in the time domain. This is achieved by creating phenological growth models for every pixel, showing how, on average, the vegetation grows as a function of time. This allows us to compare current growth, as seen by the satellite on a particular day with the model, and calculate whether the growth is on target or lagging behind where it would normally be, and express this difference in days or weeks. This will form the basis of an online service to be released in 2014, with users able to select their townland and see how growth is doing compared to average, as shown in the draft version for 2013 in Figure 2.

Measuring biomass by satellite

Moving beyond trend mapping, the next stage is to estimate grassland yield using satellites. Using historical grass growth data from Teagasc Moorepark, contained within the PastureBase service, Walsh Fellow Iftikhar Ali has been creating models of biomass (DM kg/ha) as a function of vegetation index. This work involves dealing with complex issues around scale, for example, how to compare point observations of grass growth with the area observations of VI made by satellite. These models are currently in early development and are proving successful, with modelled biomass measurements for Moorepark matching field measurements with a correlation

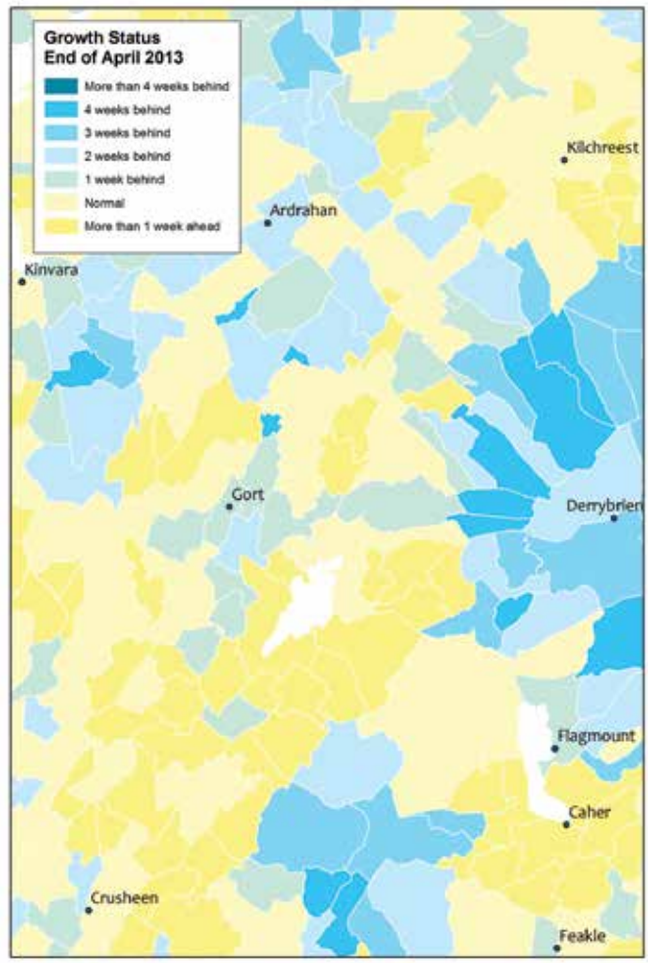


Figure 2. Example of the townland-scale growth indicators maps. This is for spring 2013 and shows how far behind (blues), or in front (yellow), in weeks, is the vegetation growth, compared to average. This is likely to be the basis of a new growth trend mapping service.

coefficient value of 0.79. In the coming years this model will be refined and combined with RADAR data to produce reliable, parcel scale estimates of standing biomass.

Future uses of satellite data

The satellites used here observe grass growing across the country, combining these observations of the current status with the grass-growth models developed in the grass programme and local meteorological forecasts will enable us to predict how grass will grow across the country at parcel scales for days or even weeks ahead.

Monitoring grass-growth trends will enable us to give the status of the national crop. This, in turn, will help establish early warning systems for future fodder crises (by detecting a poor autumn harvest or identifying and forecasting a late spring). It is hoped that within a short number of seasons, local grass growth forecasts will be available in much the same way as agricultural weather forecasts are, and be as useful.

This research is funded by the Teagasc core programme and the Teagasc Walsh Fellowship Scheme.

Rural Ireland: Decades of change

Dr David Meredith, Senior Research Officer, Rural Economy Development Programme, Ashtown, Dublin 15.
Correspondence: david.meredith@teagasc.ie

Dr David Meredith reports on the results of a population and employment study that was recently carried out on behalf of the Commission for the Economic Development of Rural Areas.

In the period 1991–2011, the number of people living in Ireland increased, the labour force grew, as did the number of people in employment. These developments impacted on the evolution of rural areas. Some rural areas benefited substantially. Others have been heavily exposed, not just to the consequences of the recent economic downturn but to long-term trends that have undermined their viability. Understanding the spatial patterns arising from these processes is critical if we are to comprehend their implications and adopt appropriate measures that will allow for better rural economic planning and development.

Population change 1991–2011

During this period (1991-2011), the population nationally increased by 30% from 3,525,609 to 4,588,198. The population living in the countryside (areas outside the cities and towns) increased by 44% (1.8 million to 2.6 million). Changes were not uniform and there was substantial spatial variation, some areas experienced very large increases in population while others experienced declines. In general, areas of the countryside close or accessible to the main cities and towns experienced growth in their populations. These areas also coincide with those that recorded lower levels of unemployment increase between 2006 and 2011, as well as larger proportions of people with high levels of educational attainment. These, therefore, are a set of increasingly strong rural areas with links to towns and cities and also robust local economies.

In direct contrast to the rural areas described above are those that lost population between 1991 and 2011. These tend to be more remote or less accessible to towns and cities. Rural places with declining populations contained 9% of the national population in 2011 and accounted for 30% of the total population decline in the 1991-2011 period, i.e. 841 Electorial Divisions (ED), both urban and rural, lost a total of 206,120 persons, 615 of these EDs are located in the countryside and these places lost 62,264 people. In marked contrast to areas experiencing high population growth there is a higher level of dependence on traditional rural industries, particularly agriculture, and a growing dependence on professional services employment, e.g. jobs in the health and education sectors. Many living in these areas left school before the age of 18 and unemployment rates are higher. These characteristics point not only to the impact of migration of younger people with higher levels of education from these areas but also to the inability of these rural areas to attract (younger) people with higher levels of education.

Employment and unemployment

Between 1991 and 2011, Ireland's labour force grew from 1,382,827 to 2,232,180, an increase of 61%. Due to the changes in the distribution of the population noted above, the labour force in the countryside grew by 53% and the numbers classified as 'at work' grew by 72% between 1991 and 2011. Counterbalancing this positive development was an increase in the numbers of people living in the countryside classified as 'unemployed', i.e. a 134% increase to 268,000. As of 2011, 69% of all unemployed persons lived in the countryside. As of 211, 69% of all unemployed persons lived in the countryside. In addition to highlighting the critical need to facilitate development of the rural economy, this data raises important questions regarding how over 250,000 people living in rural areas in 2011 found themselves to be unemployed.

The economic growth experienced during the 1990s and early 2000s brought increased employment and reduced unemployment to most areas of the country. While unemployment decreased substantially in the period between 1991 and 2006, growth during this period proved to be unsustainable. This is evident in the rapid increase in unemployment in the 2006-2011

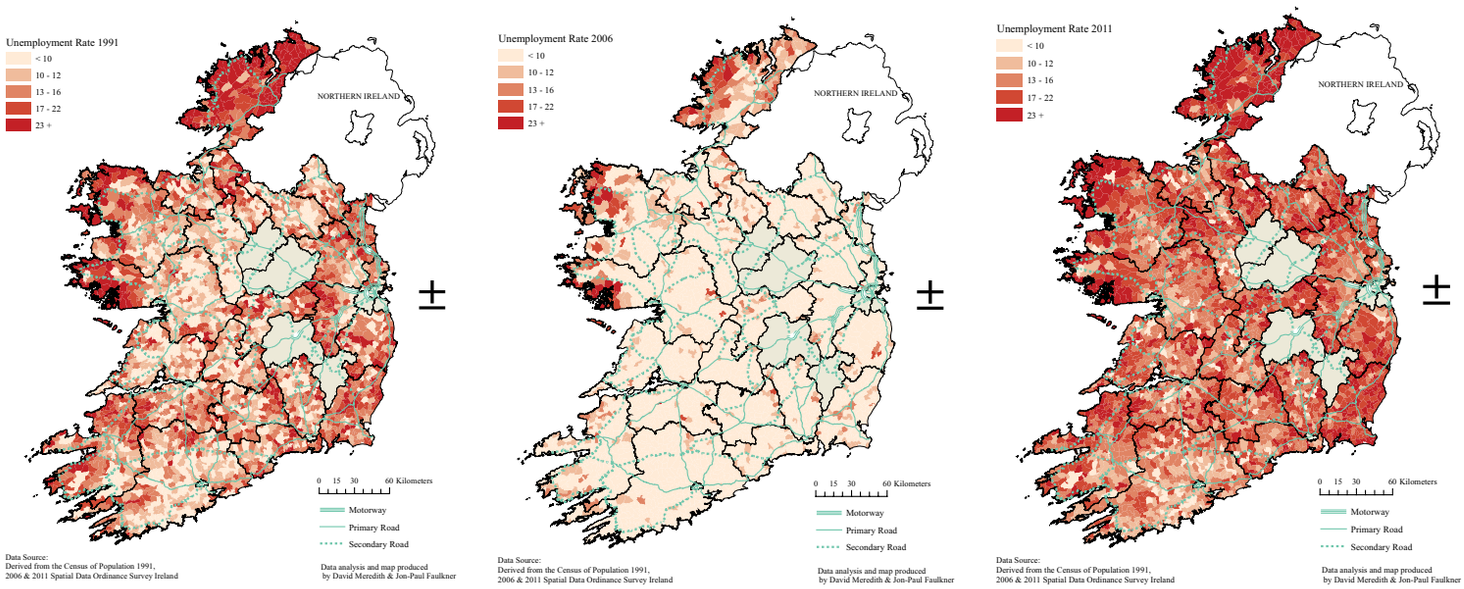


Figure1. Unemployment rate in the Republic of Ireland 1991, 2006 and 2011. The scales have been held constant for all three maps to ensure that they are directly comparable. Acknowledgement: Maps drawn by Jon Paul Faulkner.

period depicted in Map 2. While there is substantial spatial variation in the pattern of change in the unemployment rate, no part of the country escaped the effects of the economic collapse. Once again a distinction between accessible rural areas and less accessible areas can be drawn. Many less accessible rural areas saw their rate of unemployment increase dramatically. This was a consequence of a massive over-reliance on the construction sector and failure to either develop other parts of the rural economy or equip people living in rural areas with the knowledge and skills required to access employment opportunities (Meredith, 2010,2011).

Rural Ireland today

The assessment presented above highlights some of the changes reshaping rural Ireland. What is evident in the spatial patterns described above is a long-running concentration process that draws people and some types of economic activity out of more-remote or less-accessible rural areas into urban areas. This is only part of the story. The past 20 years have seen flows of people out of the cities and many towns into the surrounding countryside,. The impacts of these processes mean that accessible rural places are increasingly areas or 'zones of growth'. Less-accessible and remote rural areas have not fared as well as these zones. Decline in traditional industries combined with a general inability to retain or attract sufficient population has denuded the critical social and economic capacity of these places, particularly through the process of youth migration. It has left them with relatively weak industrial structures, exposed to consolidation of various economic sectors, e.g., farming and food processing, high levels of persistent unemployment and emigration.

This is a crude and overarching picture of the key processes of rural change and some of their implications. A more nuanced assessment identifies, within these two broad categories of rural areas, that there are distinctive subgroups of rural areas, i.e., rural areas with strong agri-food economies, rural areas that are transitioning from an agrarian-based economy to increasing dependence on the services sector, etc. Past failures to adequately understand or fully appreciate that communities that live within particular types of rural area are not homogenous, to a large degree, for the increasing disparities between different types of rural areas. Growing spatial, social and economic disparities between rural areas are a reflection of the fact that stronger rural areas are not only located in a geographically advantageous place but also have the human and social capital to identify their needs and effectively engage with the design and implementation of a variety of local, regional and national supports such that whatever strategies are devised, they can use these to further their development. Ensuring that all rural areas develop the capacity to exploit their potential in the future is a fundamental challenge facing policy makers. Failure to adequately address this issue will result in a continuation in present trends and ultimately increasing divergence between rural areas.

References

Meredith, D. (2010). 'Impact of the economic downturn on part-time farmers'. *TResearch*, 5(1): 16.

Meredith, D. (2011). 'Farm Diversification in Ireland'. *TResearch* 6(1): 34.

Carbon-neutral livestock farming: mirage or horizon point?

Ireland is at the forefront of addressing two of the world's most pressing challenges: how can we produce enough food for nine billion people and at the same time reduce greenhouse gas emissions from agriculture? Teagasc has been working closely with Departments and State Agencies to develop a vision for a productive, low-carbon agricultural sector by 2020 and by 2050, in response to the Review of the National Climate Policy.

The Irish greenhouse gas paradox

Question: Which of the following two statements is correct?

- 'The carbon footprint of Irish livestock produce is amongst the lowest in the world,' or
- 'In Ireland, agriculture accounts for a disproportionally large share of national greenhouse gas (GHG) emissions, compared to other developed countries.'

Answer: Both statements are correct. An independent assessment by the UN Food and Agriculture Organisation (FAO) reports that the emissions per unit of animal produce are lowest from the temperate grass-based livestock systems that characterise Irish agriculture. Indeed, the European Commission reports that Irish milk has the lowest carbon-footprint within the EU, and that Irish beef shares a respectable fourth place. Then, how is it that agriculture accounts for almost 30% of national GHG emissions? This is simply a reflection of the importance of agriculture to the national economy and the absence of heavy industry or large population centres in Ireland, the emissions of which 'mask' agricultural emissions in many other developed countries.

The importance of farming in Ireland's emissions profile means that agriculture has to be part of the solution in efforts to reduce national GHG emissions. At the same time, we must ensure that solutions are found within the context of food security.

Food Harvest 2020 and greenhouse gas emissions

Ireland's ambition in contributing to food security is expressed in the Food Harvest 2020 strategy (www.agriculture.gov.ie/agri-foodindustry/foodharvest2020/). Last year, we assessed the potential for reductions in agricultural emissions by 2020 in a Food Harvest 2020 scenario. In a practical sense, 2020 is 'tomorrow', in that any emission reductions are likely to be achieved through known and readily-available technologies and adoption of current best practices. We collated all these technologies and practices in a Marginal Abatement Cost Curve (MACC) for Irish agriculture, in accordance with the accounting methodologies of the International Panel on Climate Change (IPCC). Our analysis showed that increased farm efficiency offers the best opportunities to further reduce the carbon footprint of Irish produce. This includes the adoption of best practices such as extending the grazing season, accelerated gains in the Economic Breeding Index, and further gains in nitrogen efficiency. To maximise the adoption of these practices, Teagasc and Bord Bia jointly launched the Carbon-Navigator earlier this year (see *TResearch* Summer 2013, p16-17).

Together, these gains in efficiency make it technically possible to achieve the Food Harvest 2020 growth targets, without increasing agricultural GHG emissions. This is a positive outcome, as it would mean a decoupling of production from emissions, and a further reduction in the carbon-footprint of Irish food.

Expanding our ambition: towards carbon-neutral farming by 2050?

At the same time, 'flat-lining' agricultural emissions may not be sufficient in the long term to address the global challenges of climate change. It has been well established that drastic worldwide reductions in GHG emissions will be required to avert 'dangerous climate change' by 2050. This means that we have to address the question as to why it is so difficult to reduce emissions from agriculture, while maintaining food production. The answer is twofold. Firstly, almost half of agricultural GHG emissions in Ireland arise

Dr Rogier Schulte chairs the Teagasc Greenhouse Gas Working Group. **Dr Kevin Black** is Director of Forestry Environmental Research and Services Ltd. **Trevor Donnellan (second author), Dr Paul Crosson, Dr Niall Farrelly, Reamonn Fealy, Dr John Finnan, Dr Gary Lanigan, Dr Donal O'Brien, Dr Padraig O'Kiely and Dr Cathal O'Donoghue** are members of the Teagasc Greenhouse Gas Working Group and authors of the report on carbon-neutrality. **Dr Frank O'Mara** is Director of Research at Teagasc. Correspondence: rogier.schulte@teagasc.ie

from methane, which is released as a by-product of the enteric fermentation of grass by ruminants. While international research suggests that there is some scope to reduce methane emissions through breeding, vaccines or dietary additives, it is proving very difficult to alter this biological process.

The second reason relates to the current accounting methodologies of the National Inventory reports, in agreement with the Kyoto protocol. These split land-based emissions of greenhouse gases into two sectors: the agricultural sector, to which direct emissions (i.e. nitrous oxide, methane) are allocated; the Land Use, Land Use Change and Forestry (LULUCF) sector, to which emissions associated with land use are allocated. The result of this segregation is that the agricultural sector is not credited for its positive contributions in the form of carbon-sequestration or fossil-fuel displacement through bioenergy production: the credits for these activities are apportioned to other sectors, instead.

These methodological anomalies are now being recognised both at national and international policy level. The United Nations Framework Convention on Climate Change (UNFCCC) has initiated negotiations under the 'Advanced Durban Platform' to seek alternative accounting methods for agriculture, to be introduced when the second Kyoto commitment period expires in 2020. In Ireland, the Secretariat of the National Economic and Social Council (NESC) has anticipated this change by proposing a new approach for agriculture: i.e. carbon-neutrality as a horizon point for 2050. This approach examines the net balance of emissions and offsetting through carbon-sequestration and fossil fuel displacement.

Carbon-neutrality scoping study

In response, Teagasc's GHG Working Group has conducted a qualitative scoping study on both the usefulness of carbon neutrality as a concept, and its technical feasibility. First, we estimated the 'emissions gap' by 2050, i.e., the difference between emissions and offsetting. We found that in a business-as-usual scenario, carbon sequestration is likely to offset approximately one-third of agricultural emissions by 2050, with the resulting 'emissions gap' amounting to two-thirds of emissions. We subsequently assessed potential pathways to close the emissions gap, which are frequently proposed and debated in the public domain. These are:

- Accelerated carbon-sequestration, largely through increasing national afforestation rates and by reducing current deforestation rates;
- Advanced mitigation of emissions through the application of new research + knowledge transfer;
- Fossil fuel displacement through bioenergy generation, either from permanent energy crops or the anaerobic digestion of excess grass);
- Constraining agricultural production to reduce direct emissions; and,
- Acceptance that food production is associated with emissions.

We assessed each of these pathways for its potential to reduce the emissions gap, as well as its limitations. The full report can be read at: www.teagasc.ie/publications/view_publication.aspx?PublicationID=3002

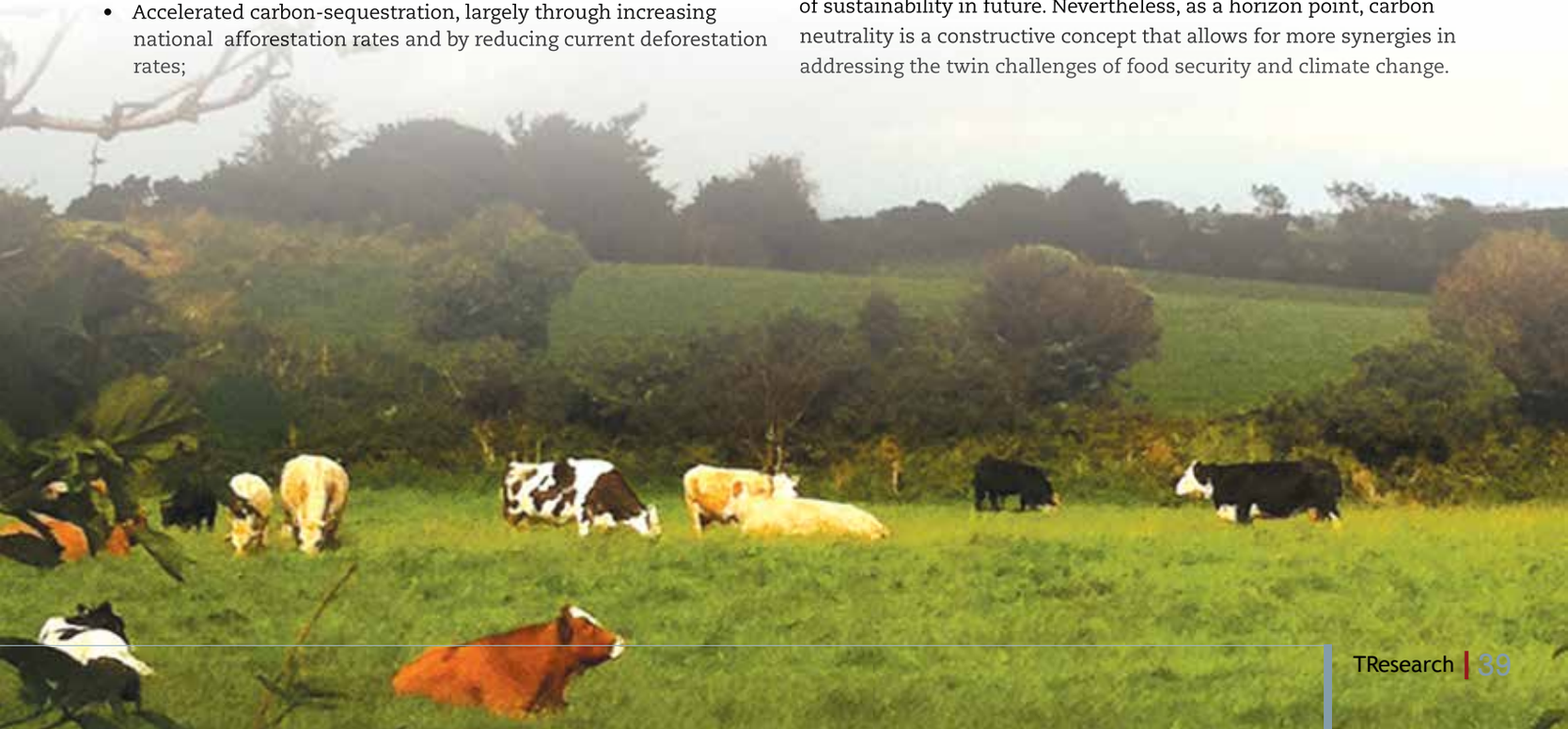
A mosaic of pathways?

While most pathways can contribute to reducing the emissions gap, each pathway has significant limitations when pursued in isolation. Therefore, an approach that pursues multiple pathways simultaneously is more likely to reduce the emissions gap by 2050:

- an accelerated afforestation scheme has significant potential to reduce the emissions gap by 2050, if initiated now;
- advanced mitigation and bioenergy generation can help in making this trajectory more realistic;
- some reduction in suckler activity has already been accounted for in the baseline projections; and,
- a remaining degree of emissions gap can be justified.

Conclusions

The concept of 'carbon-neutrality as a horizon point' radically diversifies the menu of options for agriculture to play a positive role in addressing the climate change challenge. Full carbon-neutrality may not be achievable or even desirable, as some of the approaches required to fully offset emissions could ultimately impact on water quality, biodiversity or ethical concerns (e.g., GMO's, animal welfare) – such aspects may require 'hard choices' between aspects of sustainability in future. Nevertheless, as a horizon point, carbon neutrality is a constructive concept that allows for more synergies in addressing the twin challenges of food security and climate change.



Drain, drain, sustain

Dr Tristan G. Ibrahim, Post-Doctorate Fellow
Dr Owen Fenton, Research Officer
Teagasc, Crops, Environment and Land Use Research Programme, Johnstown Castle, Co. Wexford.
Correspondence: tristan.ibrahim@teagasc.ie

Land drainage is an important component of grassland agriculture and is vital to increase or maintain productivity. Matching global trends, Irish drainage systems will continue to be modernised and maintained on existing lands.

Food Harvest 2020, the industry-led initiative, supported by Government, has set ambitious goals for Irish agriculture by targeting an increase in productivity while maintaining the protection and enhancement of the natural environment. It is expected that milk supply will increase by 57%, or an extra 540 million litres of milk will be produced by 2020 from the 2011 base. Due to the dry summer of 2013, the momentum of drainage works increased nationwide. Recent research shows how site-specific drainage design, instead of a one-size fits-all approach, is vital for optimal drainage system design. Further research now shows that green- or ecologically-engineered technologies placed at end–of-pipe locations can minimise nutrient losses from drainage systems, which bodes well for environmentally-sustainable land drainage installation in Ireland.

Worldwide, land-drainage research focuses on minimising nutrient and gas losses from drainage systems through site-specific drainage design and end-of-pipe solutions to mitigate losses before they reach the greater environment.

Coupled with site-specific drainage design, our research is aimed at: building conceptual models summarising the fundamental processes controlling nutrient losses to water and to the atmosphere in drained lands; developing metrics and new monitoring tools for assessing performances of different drainage systems with respect to such losses (i.e., to assess their environmental sustainability) and to their water removal capacity; and, designing novel remediation technologies to reduce 'unavoidable losses' (e.g., these losses that will always occur, no matter how environmentally sustainable a drainage system is).

Conceptual models

We began developing such models in an Irish context, where four drained grassland plots (uniform 1m deep piped drains arranged in a herring bone network) between 0.4 and 0.8ha in size with minimal fertilizer inputs and no grazing were monitored for more than a year. Water and nutrient losses (Figure 1) generated by the plots as overland flow (water that flows over the ground surface) and subsurface drainage flow were continuously monitored at the bottom of the slopes, while greenhouse gas (GHG) emissions to the atmosphere were measured using static chambers. In such a uniformly-drained system, one would expect water and nutrient losses to be very similar across plots. Instead, results showed that the inherent differences in the physical characteristics of the plots had a predominant impact on such losses. Smaller plots, with shallower water table, could generate more than twice the nutrient losses in overland flow per unit surface area than larger plots with a deeper water table. This occurs as there are lesser opportunities for water to infiltrate into the soil where the slope is shorter or the depth of the water table limits the storage capacity of the soil. In contrast, GHG emissions were very similar across plots, and only increased within each plot towards the bottom of the slope, as a result of the decrease in water table depth. Also, the water-table depth influenced the make-up of the nutrient pool in overland and subsurface drainage waters. For example, in areas with shallow water table, phosphorus bioavailability tends to be lower whereas ammonium and nitrate pools tend to be more abundant in overland and subsurface drainage flow, respectively.

Developing metrics and monitoring tools

In order to properly compare the sustainability of drainage systems, our group is developing a new framework whereby the cost (e.g. installation and maintenance costs, environmental costs) and benefits (e.g., increase in yields) of drainage systems are computed using weighting factors. In addition, because the assessment of the environmental sustainability of drainage systems through water and GHG sampling is labour intensive and costly, our group is developing novel monitoring tools. Biosensors, which emit a signal indicating the response of a biological element to a certain analyte (e.g., nitrate) concentration, are promising tools to substitute traditional water and gas sampling. In collaboration with researchers from the University of Sheffield (UK), a Teagasc Walsh Fellow PhD project

Figure 1. Tanks, V-notch weirs and automatic samplers installed at the bottom of grassland plots to monitor water volumes and nutrient losses in overland and subsurface drainage flow.

seeks to create critical mass in this research area. The aim of the project is to identify molecular fingerprints that characterise drainage system function, paving the way for an innovative biosensor that can evaluate potential loss pathways within a drainage system.

Remediation technologies

No matter how environmentally sustainable a drainage system is, unavoidable nutrient losses to water and to the atmosphere are likely to occur during and after its installation as a result of a modification of the physical characteristics of the soils, and of a likely increase in fertilizer inputs to the land. End-of-pipe solutions are seen internationally as a means to counteract such losses. Initially, our work focused on so-called denitrifying bioreactors, which can be described as a volume of reactive media, either as a trench in the ground to intercept contaminated groundwater or as an end-of-pipe solution connected to a drainage outlet. An organic, carbon-rich media (e.g., woodchip) enhances the microbial reduction of nitrate into benign di-nitrogen gas. Our preliminary experiments using laboratory columns showed that several carbon media (e.g., woodchip) were able to remove 99% of nitrate in slow-moving water. Such good performances were counterbalanced by 'pollution swapping', i.e., the production of other contaminants inside the bioreactor, either in water (e.g., as ammonium and phosphorus) or as GHG. Subsequently, we undertook a semi-controlled field experiment in a 9x3x1.5m pilot-scale, outdoor facility divided into seven interconnected cells filled with sand and woodchip, where nitrate-enriched water was circulated and hydrochemistry and GHG emissions monitored along flowpaths. This design allowed for the control of water flowpath length, i.e., allowing enough interaction between contaminated water and the reactive media so that remediation of all nitrate occurred, while limiting pollution swapping. Although efficient, this design needs to be complemented by additional remediation sequences, such as a biochar cap to reduce nitrous oxide emissions in the area of denitrification, or a zeolite cell allowing for ammonium or phosphorus sequestration. Such multi-remediation technologies are the way forward, as they can minimise pollution swapping while remediating mixed contaminant sources (e.g., ammonium and phosphorus in addition to nitrate). Also, they offer the potential for enhancing nutrient efficiency in farms, by nutrient stripping and recycling (e.g., nutrient-saturated zeolite can be spread back into the land as a fertilizer). Internationally, the woodchip bioreactor and the additional reactive media sequences are separated on the landscape but it is our research goal to merge them into a single remediation technology termed a 'permeable reactive interceptor' targeting artificial drainage and spring outlets.

Conclusion

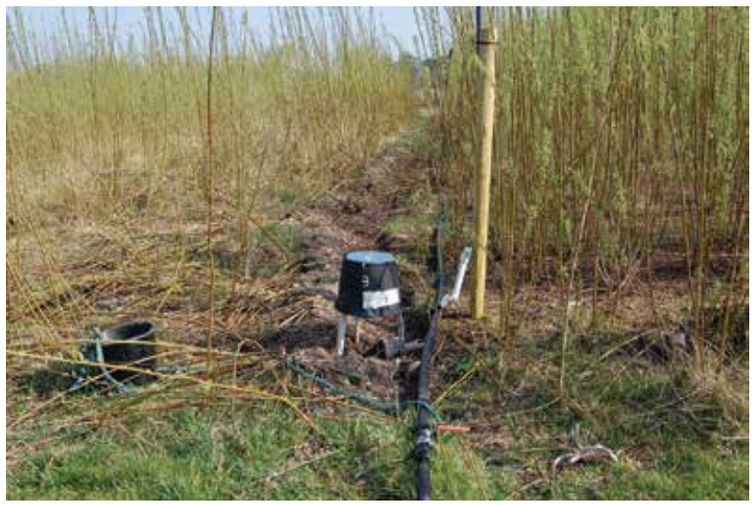
From a production perspective, it is a good idea to drain suitable lands in Ireland and land drainage will help achievement of goals set out in Food Harvest 2020. There are cases where nutrients and gases will be lost but the research is now in place to mitigate such losses before they have a deleterious effect on the environment.

This research is supported by the Teagasc core fund and the Department of Agriculture, Food and the Marine's Research Stimulus Fund.

Related publications

Healy, M.G., Ibrahim, T.G., Lanigan, G., Serrenho, A. and Fenton, O. (2012). 'Nitrate removal rate, efficiency and pollution swapping potential of different organic carbon media in laboratory denitrification bioreactors'. *Ecological Engineering* 40: 198-209. 10.1016/j.ecoleng.2011.12.010.

Ibrahim, T.G., Healy, M.G., Richards, K.G., Fealy, R.M. and Fenton, O. (2013). 'Spatial and temporal variations of nutrient loads in overland flow and subsurface drainage from a marginal land site in South East Ireland'. *Biology and Environment*, 113B (2): 1-18. 10.3318/BIOE.2013.01.



Dr Paul Galbally, Research Officer, Teagasc, Crops, Environment and Land Use Research Centre, Oak Park, Co. Carlow
Dr Eilín Walsh, Research Assistant, UCD School of Biosystems Engineering, **Dr John Finnan** and **Declan Ryan,** Research Officers, Teagasc, Crops, Environment and Land Use Research Centre, Oak Park, Co. Carlow
Dr Kevin P McDonnell, Senior Lecturer, UCD School of Agriculture and Food Science.

Multi-functional bioenergy crops

Teagasc and University College Dublin researchers are using energy crops to filter organic waste

Healthy, well-maintained soil is essential for good crop growth and clean water essential for man and the environment. When considered as a whole, nutrient elements are contained in either available or unavailable pools, the majority usually in the latter. Nutrients in the available pool are either retained in soil, lost through drainage (or surface loss), or taken up by crops. Unless the soil nutrients removed by crops, or lost to groundwater or surface water, are replenished, the available nutrient pool rapidly becomes depleted. Soil nutrients can be restored by application of commercial fertilizers (most commonly) or by application of organic sources of nutrients (traditionally this has involved surface application of animal slurries and manures). Organic wastes from municipal treatment works (e.g. sewage sludge) and some industrial organic wastes can also be used as sources of fertilizer. Because of their generally high-organic-matter content and slow release of nutrients, organic wastes can contribute to long-term soil fertility. The EU Sewage Sludge Directive seeks to encourage the use of treated sludges in agriculture; regulating their use to prevent harmful effects on the soil, flora and fauna.

Concerns

One of the concerns with sewage is their content of heavy metals, although the heavy metal content of these sludges is usually similar to that of agricultural wastes such as slurries and farmyard manure. However, not all heavy metals are bad news for crops: chromium, copper, and zinc are essential micronutrients. At very high concentrations, however, micronutrients can become toxic; it is essential, therefore, that the application of organic by-products does not raise concentrations of heavy metals to toxic levels. Losses of nutrients (and metals) from soil systems to rivers, waterways and lakes must also be carefully considered before any organic materials can be applied, particularly in the case of P, as P loss can result in serious degradation of surface-waters through eutrophication. Therefore, the characteristics of organic material, the receiving soil, and the crop must all be carefully considered before any organic material is applied.

Because of the origin of some organic by-products (e.g., sewage sludge) there is a reluctance to use such materials to fertilise soil used to grow food crops. In terms of sludge disposal, therefore, much recent research has focused on using energy crops as a biological filter for organic waste materials. This is due to several factors such as: non-entry into the food chain, low nutrient requirements, hardiness, and the fast growth rates of energy crops.

Willow and *Miscanthus* application

The fate of heavy metals and nutrients after sludge application to short rotation coppice willow and *Miscanthus* plantations was examined in a three-year study conducted at Teagasc, Crops, Environment and Land Use Research Centre, Oak Park, Carlow. The treatment programme was for a maximum application (with P as the limiting factor), an intermediate application and a control.

Biosolid being spread on Miscanthus.

Willow irrigation system.

Installation of V-notch weir, and overland flow indicator (plus protective bucket with solar panel for power). Note the brewer's waste irrigation pipe in the top right hand corner of the picture.

Two organic by-products were applied to both crop types: brewer's waste (spread via an irrigation system), which is a by-product of alcoholic beverage production; and biosolids (treated sludges from wastewater treatment plants), which were spread using a disc-type slurry spreader. Prior to application of the organic by-products, a baseline check of the background conditions was conducted and concentrations of nutrient and heavy metals in soil and adjacent surface- and ground-waters were measured following application.

Analysis of water samples

The ground-water samples were collected from multiple groundwater wells sunk into each plot and bulked to create a representative groundwater sample; each sample was filtered and analysed at Teagasc Johnstown Castle, Co. Wexford for N, P, K and heavy metals (Cd, Cr, Cu, Pb, Zn, and Ni). Surface-water samples (or more correctly, overland flow samples) were collected using V-notch dams with associated grab-samplers positioned in the lowest corner of the shallow trench (berm) that ran around the edge of each plot. A series of overland flow (OLF) timers were attached to a V-notch weir, which switched 'on' when overland flow was present and 'off' when it was not; giving times and durations for individual OLF events that could be cross checked against rainfall and other OLF experiments nearby. This allowed exports to be determined from concentrations in samples, and flows and durations of OLF from each plot. A series of what were termed 'proportional samplers' was also installed to provide more accurate data on concentrations and exports of each nutrient from each plot.

Soil and crop analyses

Soil and crop were sampled annually, including prior to the spreading of any by-products on the experimental plots. Several trenches were dug close to each of the sites to characterise the soil and nature of the groundwater layers; samples of soil were also taken from borings during the installation of groundwater wells on each of the plots. Nutrient and heavy metal exports were calculated from the concentrations and from the volumes of drainage and overland flow, as well as measurements of crop uptake.

Results

Immobilisation in soil and crop uptake were the most significant removal routes for available nutrients and heavy metals, following waste application. There was evidence of heavy metal build-up in soils under the SRC willow plots; however, for all heavy metals (except Cr) these increases were modest, indicating metal uptake by the willow crop. For *Miscanthus* plots, there was little evidence of heavy metal build up in soils for either organic by-product except for a small increase in Cd concentration on the plot treated with the maximum rate of brewer's waste. No soil quality thresholds were exceeded by any heavy metals applied to soil, which was a function of their low concentrations in the by-products and the low rates at which by-products were spread.

Phosphorus leached through soil under *Miscanthus* plots and both phosphorous and potassium leached through soil in SRC willow plots. In some cases, quality thresholds established for groundwater were exceeded as a result. Copper also leached to groundwater but quality thresholds were not breached. Overland flows to surface-waters were very small compared to total precipitation or drainage (drainage to groundwater accounted for roughly 99% of excess rainfall, surface flows about 1%), therefore, surface exports of nutrients and heavy metals was very low and posed no threat to nearby surface-water bodies. The combined results from all aspects of the study also indicate that (at the scales and application rates examined) neither nitrate nor any of the heavy metals posed a risk to either surface-water or ground-water quality.

Potential as biological filter

This research demonstrates the utility of using energy crop plantations as biological filters and strengthens the case for applying organic waste to non-food crops without environmental risk. Sewage sludge is the waste that is most likely to be applied given the large quantities and widespread availability of this waste requiring disposal. The environmental risk associated with the use of sewage sludge should not be dissimilar to that of agricultural wastes, as the composition of sewage sludge is similar to that of agricultural waste. The use of energy crops as biological filters opens up an additional avenue of potential revenue for farmers through gate fees. Given the rise in biosolids production in Ireland, the application of organic by-products to energy crops is worth investigating for environmental and financial reasons.

This project was funded by the Department of Agriculture, Food and the Marine's Research Stimulus Fund.

Events

JANUARY

9 January — *Teagasc Food Research Centre, Ashtown, Dublin 15*

Nanotechnology in the Agri-food Industry: Applications, Opportunities & Challenges

Presented by *safefood*, the Institute for Global Food Security, Queen's University Belfast, and Teagasc Food Research Centre, this workshop is dedicated to raising awareness of the potential applications of nanotechnology in the agri-food sector (including feed and food ingredients; intelligent packaging; and clever detection systems), examining factors influencing consumer acceptance and improving understanding of the potential impacts of nanotechnology across the agri-food sector on the island of Ireland.

Registration: katrina.campbell@qub.ac.uk www.teagasc.ie/events/

29 January — *Teagasc, Moorepark, Co Cork*

Workshop for Teagasc Walsh Fellowship Supervisors

Creating the Seven Secrets of Highly Successful Research Students (for supervisors of Walsh Fellowship PhD students). This workshop will last for 2.5-3 hours and will be facilitated by Dr Hugh Kearns. Places will be allocated strictly on a first-come, first-served basis.

Contact: hilary.king@teagasc.ie

30 January — *Lyrath Hotel, Kilkenny*

National Tillage Conference 'Understanding Variability to Improve Precision and Profit'

The morning session is themed around variation in crop growth, nitrogen requirement, spring barley quality for malting and planned development of precision farming suitable for Irish tillage farmers as part of the second round of BETTER farms.
The afternoon session will cover the emerging issue of resistance to insecticides in cereal aphids and resistance to fungicides and disease control programmes for cereals.

Contact: eleanor.butler@teagasc.ie

FEBRUARY

7 February — *Teagasc Food Research Centre, Ashtown, Dublin 15*

Waste Not Want Not - Recovering Value from Food Waste

Presenting research and development outcomes from exploring the potential for the utilisation of by-products (waste) from food processing and showcasing potential exploitation routes. Is there hidden value buried in your waste?
This exciting event provides an opportunity for food-processing companies and, in particular, small- and medium-sized enterprises (SMEs) and food entrepreneurs to interact with researchers on potential technology opportunities from the Department of Agriculture, Food and Marine-funded Food Research Programmes. The workshop will be of interest to stakeholders with an interest in all points along the food chain, particularly those interested in assessing the hidden potential contained in waste materials and by-products of food processing. A range of commodities will be covered including plant, meat and dairy waste streams.

Register online: www.teagasc.ie/events/

MARCH

10-11 March — *Tullamore Court Hotel, Tullamore, Co. Offaly*

Agricultural Research Forum

The objective of the meeting is to provide an opportunity for the presentation and publication of new scientific information relating to the Sciences of Agriculture (including animal and crop science, molecular biology and biotechnology), environment, soil, food, agri-economics and forestry. The conference places emphasis on novel, high-quality research and on the professional presentation of results. The forum will provide an opportunity for scientists, specialists, advisors and others working in the above areas to interact and exchange views. Participation by industry personnel is particularly welcome.

Contact: mark.mcgee@teagasc.ie www.agresearchforum.com

27 March — *RDS, Dublin*

Teagasc/RDS Lecture Series - Lecture 5: Is Better Global Governance of the Food System the Answer?

Dr Maximo Torero is the Division Director of the Markets, Trade, and Institutions Division at the International Food Policy Research Institute (IFPRI), Washington DC, leader of the Global Research Program on Institutions and Infrastructure for Market Development and Director for Latin America. He has 15 years' experience in applied research and in operational activities. Prior to joining IFPRI, he was a senior researcher and member of the executive committee at Group of Analysis for Development (GRADE). He received his PhD from the University of California at Los Angeles, Department of Economics and held a postdoctoral fellow position at the UCLA Institute for Social Science Research (ISSR). He is also a professor on-leave at the Universidad del Pacífico, and Alexander von Humboldt Fellow at University of Bonn, Germany. He has won the World Award for Outstanding Research on Development given by the Global Development Network (GDN) twice.

Register online: www.teagasc.ie/events/rds-lecture-series/

For a list of Teagasc's Food industry training schedule please see: http://www.teagasc.ie/food/research/training/schedule.asp
For presentations from previous Teagasc events see: http://www.teagasc.ie/publications/