TEAGASC

Research

Volume 11: Number 4. Winter 2016 ISSN 1649-8917

Research and innovation news at Teagasc www.teagasc.ie

Returns on afforestation of agricultural land

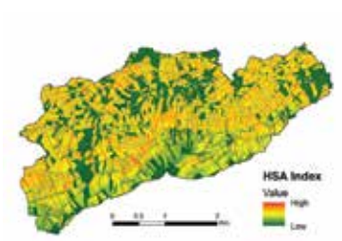
Rapeseed for heart health

Teagasc Lamb Production Model

Science Week – Festival of Farming and Food

Agriculture and Food Development Authority

Contents



20

26

16

34

Teagasc | Oak Park | Carlow

Agriculture and Food Development Authority

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

ADMINISTRATOR Ann Tiernan ann.tiernan@teagasc.ie

Science communication and outreach

Teagasc recently held a series of science outreach events as part of one of 11 Science Foundation Ireland (SFI)-sponsored Science Week festivals. The aim of the 'Festival of Farming and Food – SFI "Science Rising" at Teagasc' was to raise awareness of the importance and impact of agriculture and food research on everyday lives and the Irish economy.

This goal aligns with SFI's main aims for Science Week, which include inspiring young people to engage with science, technology, engineering and mathematics (STEM) and take up careers in those fields; and to demonstrate the importance and relevance of STEM to our everyday lives and to the future development of Irish society and the economy.

Events were held at Teagasc research centres around the country and there were many other events (e.g., Science Week at Rustic Stone with celebrity chef Dylan McGrath) and initiatives (e.g., the Science Apprentice series of books) that Teagasc staff contributed to.

Put simply, these events inspire young people to undertake careers in science, showing them the options that are available and also showing them that scientists are normal people. The contribution of all Teagasc staff and students, who made these events a success, is greatly appreciated.

In addition to Science Week, Teagasc has partnered with SFI for a number of other science outreach activities, in particular Smart Futures and SciFest, where many Teagasc staff and student volunteers have spoken at careers events at secondary schools and third-level colleges around the country.

As consumers and society in general become more questioning of science and as the amount of information (some of it of questionable quality) available to them increases, it is very important for scientific organisations like Teagasc to engage with the public and explain what we are doing, why we are doing it, and the benefits that it will bring. We see engagement in science outreach activities as a very effective way of doing this.

Our next science outreach event is in January 2017, where Teagasc will exhibit at the BT Young Scientist & Technology Exhibition in the RDS, Dublin, and sponsor a special award at the event. We are not only exhibiting but have dealt with many queries and assisted many students in their research projects in the run-up to the event. Please come along and visit our stand at the event, which features Teagasc's Foresight 2035 project and asks young visitors about their vision of farming and food in the future.

Catriona Boyle
Science Communications and Outreach, Teagasc Head Office

Frank O'Mara
Director of Research, Teagasc

Cumarsáid agus for-rochtain eolaíochta

Reáchtáil Teagasc sraith imeachtaí for-rochtana eolaíochta le déanaí mar chuid de cheann amháin den 11 fhéile arna n-urrú ag Fondúireacht Eolaíochta Éireann (FEÉ) le haghaidh na Seachtaine Eolaíochta. Ba é an aidhm a bhí ag an "Festival of Farming and Food – SFI 'Science Rising' at Teagasc" ("Féile na Feirmeoireachta agus an Bhia – 'Éirí Eolaíochta' FEÉ ag Teagasc") ná feasacht a mhéadú ar cé chomh tábhachtach agus chomh hábhartha atá an talmhaíocht agus taighde bia don saol laethúil agus don gheilleagar.

Tagann an sprioc sin le príomhaidhmeanna FEÉ le haghaidh na Seachtaine Eolaíochta, lena n-áirítear daoine a spreagadh le páirt a ghlacadh in eolaíocht, teicneolaíocht, innealtóireacht agus matamaitic (STEM) agus tabhairt faoi ghairmeacha sna réimsí sin; agus a thaispeáint cé chomh tábhachtach agus chomh hábhartha atá STEM dár saol laethúil agus d'fhorbairt shochaí na hÉireann agus an gheilleagair sa todhchaí.

Reáchtáladh na himeachtaí in ionaid taighde de chuid Teagasc timpeall na tíre agus b'ann do roinnt mhaith imeachtaí eile (e.g. an tSeachtain Eolaíochta ag Rustic le Dylan McGrath, an cócaire mór le rá) agus do roinnt mhaith tionscnamh eile (e.g. sraith leabhar Science Apprentice) ar chuir foireann Teagasc leo, i measc nithe eile. Go bunúsach, is éard a dhéanann na himeachtaí sin ná daoine óga a spreagadh le tabhairt faoi ghairmeacha in eolaíocht ach na roghanna atá ar fáil dóibh a léiriú agus a thaispeáint dóibh gur gnáthdhaoine iad eolaithe. Is mór an meas atá ann ar ról na mball foirne agus na mac léinn ar fad de chuid Teagasc a chuir le rath na n-imeachtaí sin.

De bhreis ar an tSeachtain Eolaíochta, chuaigh Teagasc i gcomhpháirt le FEÉ le haghaidh roinnt gníomhaíochtaí eile for-rochtana eolaíochta, go háirithe Smart Futures agus SciFest, áit ar labhair roinnt mhaith ball foirne agus oibrithe deonacha is mic léinn de chuid Teagasc ag imeachtaí gairmtheorach i meánscoileanna agus i gcoláistí tríú leibhéal timpeall na tíre.

De réir mar a mhéadaíonn an méid a cheistíonn tomhaltóirí agus an tsochaí i gcoitinne an eolaíocht agus de réir mar a mhéadaíonn an méid faisnéise (a bhfuil roinnt de ar chaighdeán amhrasach) atá ar fáil dóibh, tá sé ríthábhachtach go ndéanann eagraíochtaí eolaíochta amhail Teagasc teagmháil leis an bpobal agus go dtugaimid míniú ar an obair atá ar bun againn, ar an bhfáth a bhfuil sí ar bun againn agus ar na tairbhí a bhainfear aisti. Measaimid gur bealach an-éifeachtach le déanamh amhlaidh atá i ngníomhaíochtaí for-rochtana eolaíochta.

Is i mí Eanáir 2017 a bheidh ár gcéad imeacht for-rochtana eolaíochta eile ar siúl. Ag an imeacht sin, beidh Teagasc i mbun taispeána ag taispeántas Eolaithe Óga agus Teicneolaíochta BT i gCumann Ríoga Bhaile Átha Cliath, Baile Átha Cliath, agus déanfaidh sé dámhachtain speisialta ag an imeacht a urrú. Ní hé amháin go bhfuilimid i mbun taispeána, phléamar leis an iomad ceist agus chabhraíomar le lear mór daltaí sna seachtainí roimh an imeacht maidir lena dtionscadail taighde. Tar thart agus féach ár seastán ag an imeacht. Léireofar tionscadal Foresight 2035 de chuid Teagasc ag an seastán agus cuirfear ceisteanna ar chuairteoirí óga faoin bhfís atá acu faoin bhfeirmeoireacht agus faoi bhia sa todhchaí.

Catriona Boyle
Cumarsáid agus For-rochtain Eolaíochta, Ceannoifig Teagasc

Frank O'Mara
Stiúrthóir Taighde, Teagasc

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: Ciarán Brougham, Martin Whelan
Editorial: Oonagh O'Mahony

TResearch is available online as PDF or digital edition, see www.teagasc.ie/publications/tresearch

John Tobin

John Tobin has worked as a Senior Research Officer in the Food Chemistry and Technology Department at Teagasc Food Research Centre Moorepark since 2015, and was recently appointed head of this department.

As a senior researcher, John leads a programme of applied research focusing on the links between dairy science, process technology and process engineering. He is involved in process technology platforms, which include thermal processing, evaporation, spray drying, homogenisation, high shear technologies and separation/fractionation technologies. His primary areas of expertise revolve around the complete deconstruction of milk by filtration and separation technologies, coupled with mapping of the physical partition of milk components during fractionation. John is also extensively involved in thermal processing, particularly relating to the controlled denaturation and aggregation of protein streams in both low and high dry matter environments. His experience in thermal processing covers both direct (PHE/THE) and indirect (steam injection/infusion) technologies, and also delves into the stability and interactions of complex nutritional formulations within all facets of thermal and concentration processes. John's additional research interests include novel and emerging process technologies such as microwave volumetric heating, cavitation pumping, forward osmosis and inline process analytical technologies such as viscosity sensors. John currently supervises five post-doctoral researchers and two post-graduate students.

John graduated with an Honours BSc in Food Science and Technology from University College Cork in 2006, following which he joined Teagasc as a Walsh Fellow to begin his PhD studies, in collaboration with UCC. In 2009, John joined Teagasc as a Research Officer investigating the potential of novel thermal processes with applications for the infant formula sector. In 2011, he joined the R&D team of Danone, Nutricia Early Life Nutrition, where he worked as a senior process technologist, before rejoining Teagasc in 2015.

As a result of the applied nature of his research, John has developed strategic collaborations with a number of commercial industry partners. He is also working synergistically with research organisations throughout Ireland – including, University College Cork, University of Limerick, Dublin Institute of Technology, University College Dublin and Cork Institute of Technology – as well as being involved in a number of cross-centre collaborations in Teagasc with researchers at Teagasc Food Research Centre, Ashtown and the Animal and Grassland Research Innovation Centre, Moorepark.

Agri journalism award

An article in Teagasc's *TResearch* magazine was shortlisted in the Best Technical Article category in the recent Guild of Agricultural Journalism awards.

'The Future is Bio' appeared in the Winter 2015 issue of *TResearch* and was written by Laura Devaney/ Maeve Henchion, Rural Economy and Development Programme.

Over 200 entries were submitted to the awards, of which 15 were shortlisted by an esteemed jury.

Teagasc/Penn State University collaboration talks

Helen Grogan, a mushroom researcher in the Horticultural Development Department, Teagasc, spoke at the 2016 Pennsylvania State University (PSU) Mushroom Short Course, a continual professional development event that is held every year for the North American mushroom industry. She gave a keynote speech on the 'Epidemiology and Control of the compost green mould pathogen - *Trichoderma aggressivum*'. The speech was very well received and helped to explain some of the reasons why Bulk Phase 3 mushroom production has struggled to succeed in Pennsylvania. Helen also spent time visiting the Department of Plant Pathology and Environmental Biology, where she gave a seminar to undergraduate and graduate students, and also got to meet many of the horticulture researchers at the Department. She is looking to develop collaborative links with PSU's John Pecchia and Carolee Bull on mushroom research topics of mutual interest such as mushroom strain development, mushroom casing microbiology and mushroom compost utilisation.

John Pecchia, PSU, and Helen Grogan, Teagasc, at the PSU Nittany Lions football game prior to the PSU 2016 Mushroom Short Course.

ProU functional yoghurt

ProU is a new functional yoghurt product offering consumers on the Irish and UK markets high levels of calcium, vitamin D and protein in combination. This yogurt is the brainchild of Michael and Jane Murphy. The Murphys identified a lack of tasty food products that are dedicated to looking after longer term bone and muscle management. They have developed a proprietary process with Teagasc as part of the FoodWorks programme to deliver a unique and tasty food product that targets bone and muscle health management.

10 Things to Know About … Beef and Beer

Teagasc researchers Donagh Berry and Paul Allen recently appeared on the science television series '10 things to know about … Beef and Beer'. Pictured is Paul Allen talking to presenter Kathriona Devereux.

New appointments in Teagasc Food Research Programme

As part of a restructuring of the Teagasc food research programme, which is headed up by Mark Fenelon and located across two campuses at Ashtown in Dublin and Moorepark in Co Cork, a new Food Quality and Sensory Science department has been introduced. This increases the number of departments from four to five. Five new appointments have been made to manage these food research departments:

- Ciara McDonagh - Head of Food Industry Development Department;
- Geraldine Duffy - Head of Food Safety Department;
- John Tobin - Head of Food Chemistry and Technology Department;
- Eimear Gallagher - Head of Food Quality and Sensory Science Department; and
- Paul Cotter - Head of Food Biosciences Department.

Mark Fenelon, Head of Food Programme, Teagsc said: "Core areas of research are being strengthened with the inclusion of new themes within the programme that align Teagasc food research priorities with the Food Wise 2025 strategy for the Irish Agri-Food industry. These include life-stage nutrition and healthy eating, application of sensory science and flavour chemistry, emerging technologies and food fermentation."

Poncelet prize

André Brodkorb, Senior Researcher in the Food Chemistry and Technology Department at the Teagasc Food Research Centre Moorepark in Fermoy, Co Cork, was honoured with the Poncelet Prize for Innovation in Encapsulation Technology 2016 at the 24th International Conference on Bioencapsulation in Lisbon, Portugal. The Prize, co-sponsored by Procter & Gamble and the Bioencapsulation Research Group (BRG), was established in 2011 to honour leadership and contributions to the field of bioencapsulation and microencapsulation. André presented a keynote lecture at the conference and contributed a short paper to *Bioencapsulation Innovations*, the newsletter of the BRG. The Poncelet Prize includes a trophy, a monetary amount provided through Procter & Gamble's sponsorship and a travel award provided through the BRG's co-sponsorship support.

Microbes in raw milk

A Teagasc paper, which was recently published in *Applied and Environmental Microbiology*, was the subject of a blog on the American Society for Microbiology website. The paper relates to tracking the flow of microbes, from the environment into raw milk, using high-throughput DNA sequencing technologies. The research of authors, Conor Doyle and Paul Cotter, is funded through the Teagasc Walsh Fellowship Scheme and Teagasc core funding.

Green Pastures

Results from research, which is being led by Teagasc and UCC researchers and includes APC Microbiome Institute's Catherine Stanton at Teagasc Moorepark Food Research Centre and Paul Ross in UCC, indicate that milk and dairy produce from grass and clover-fed cows has significantly higher concentrations of fat, protein and casein. Tom O'Callaghan, PhD student at Teagasc says: "In particular, milk from pasture-fed cows (grass or clover) has significantly higher concentrations of healthy fatty acids. These differences are reflected in butter produced from pasture-fed cows being superior in appearance, flavour and colour, as confirmed by sensory panel data. Pasture-derived butter is also nutritionally superior for heart health with lower atherogenecity scores and containing significantly higher concentrations of CLA (c9t11), a healthy fatty acid and β-carotene, which gives the butter a lovely golden colour."

Tom was the lead author on two papers on the topic, which were recently published in the *Journal of Dairy Science* and were selected as the Editor's Choice.

"The significance of these results is that they provide scientific substantiation for what we long thought to be the case – that dairy produce from pasture-fed animals is superior, from a compositional and nutritional perspective, to those derived from their indoor counterparts," said Paul Ross.

Catherine Stanton, Teagasc, added:"The next step is to demonstrate that this has a long-term, positive influence on human health through clinical studies."

Professorships

The title of Visiting Professor (University of Sheffield) has been conferred on Owen Fenton of Johnstown Castle Crops, Environment and Land Use Research Centre.
Catherine Stanton, Teagasc Food Research Centre, Moorepark, has recently been appointed as Research Professor at University College Cork.

Spin out company

A company Artugen Therapeutics Ltd has been recently established as a spin-out from University College Cork (UCC), with an investment of almost €1.4 million by Morningside Investments, the global private equity vehicle owned by Hong Kong's billionaire Chan family. The company, focused on developing an antimicrobial agent that can kill the deadly Clostridium Difficile bacterium, which is resistant to antibiotics, is based on a patented technology the company licensed from Teagasc and UCC jointly in 2016. This technology was developed through a joint Teagasc/UCC project, associated with the SFI funded Alimentary Pharmabiotic Centre, Cork with inventors on the patent including Mary Rea from Teagasc Food Research Centre, Moorepark, Paul Ross of University College Cork and Colin Hill of UCC.

Walsh fellowships seminar winners

Aideen Kennedy won the RDS medal for the best oral presentation at the Teagasc Walsh Fellowship seminar during Science Week. Aideen is based at the Teagasc Animal and Grassland Research and Innovation Centre, Moorepark and at the Department of Biological Sciences, Cork Institute of Technology. The title of her presentation was: 'Epidemiological investigations into Johne's disease on Irish dairy farms'.
The Best Food Research Presentation and winner of the Institute of Food Science and Technology Ireland (IFSTI) medal was Aoife Buggy. Aoife is based at the Teagasc Food Research Centre, Moorepark and at the Department of Chemistry in the National University of Ireland Maynooth. The title of her presentation was: 'Effect of α-lactalbumin concentration on the stability of infant milk formula under differing process conditions'.
The award for the best poster went to Jessica Coyne, who is based at the Teagasc Animal and Grassland Research and Innovation Centre in Moorepark. She also works with the Biometrical Genetics Department at the Natural Resources Institute Finland (Luke), and at the Department of Agricultural Science in the University of Helsinki in Finland. Jessica's presentation was titled: 'Genetics of longitudinal growth and feed efficiency data'.
Thirteen PhD Walsh Fellow Students made oral presentations of their research findings at the seminar. In addition, 42 Walsh fellows presented posters outlining their research.
Articles based on the winning papers will appear in the spring 2017 issue of *TResearch*.

Aideen Kennedy, Winner of the RDS Medal at the Teagasc Walsh Fellowships Seminar.

IJAFR papers

Volume 55, No. 2, 2016 of the *Irish Journal of Agricultural and Food Research* contains the following papers:

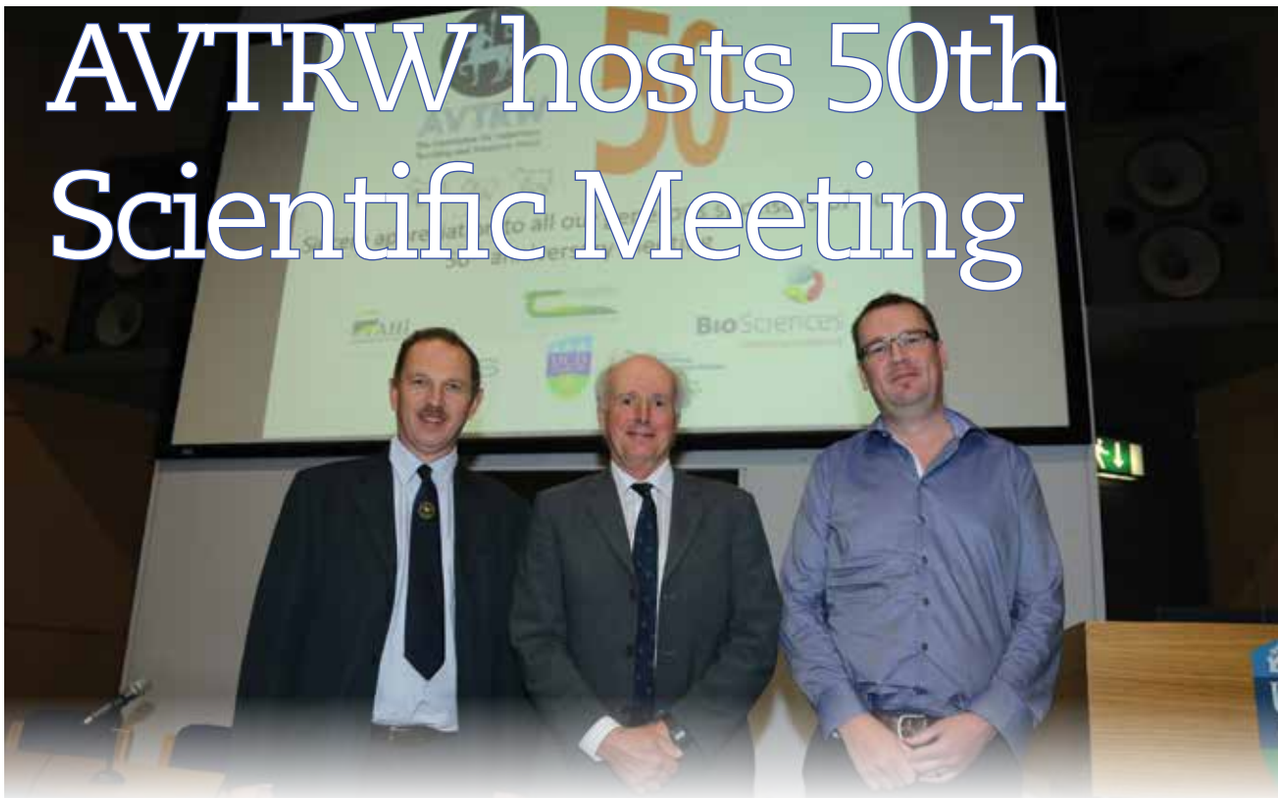
- Comparison of methods for the identification and subtyping of *E. coli* serotypes (Prieto-Calvo *et al.*)
- Determining optimum duration for soil water characteristic curves (Vero *et al.*)
- The costs of seasonality and expansion in Ireland's milk production and processing (Heinschink *et al.*)
- Developing farm-level sustainability indicators for Ireland using the Teagasc National Farm Survey (Ryan *et al.*)
- Lactose demand in New Zealand and Ireland (Sneddon *et al.*)
- Response of two-row and six-row barley to fertilizer N under Irish conditions (Hackett)
- Presumptive *Bacillus cereus* in Irish dairy farms (O'Connell *et al.*)
- Ammonia emissions from six Irish soil types (Burchill *et al.*)
- Feeding behaviour and calf health (Johnson *et al.*)
- Effect of omitting teat preparation on bacterial levels in bulk tank milk (Gleeson *et al.*)
- Conservation of semi-natural grasslands (Ó hUallacháin *et al.*)
- Behaviour of tail-docked lambs (Marchewka *et al.*)

To view these papers and to sign up for e-Table of Content or new article alerts, see: http://bit.ly/IJAFR2016

Outlook 2017

Analysis produced by Teagasc economists indicates that farm margin fell on most farms in Ireland in 2016. Supplies of milk, beef and grain internationally have been running ahead of demand and this has led to a fall in farm prices.
Lower production costs in 2016 offset some of the effects of falling output prices. For the second year in a row, lower oil prices led to a significant fall in fuel prices. There was also a gradual decline in fertilizer prices over the course of the year.
The outlook for 2017 is mixed. A slowdown in growth in global milk production should mean that dairy margins will increase in 2017, with milk prices forecast to be 20% higher. Irish milk production should also increase, providing an additional boost to the bottom line.
By contrast, the Irish beef sector is facing into a difficult year in 2017. Beef supplies across the EU are forecast to increase next year. Demand for beef in the EU is not particularly strong and EU beef prices are likely to fall by up to 10%. Given that the UK market is particularly important for Irish beef exports, the weakness of sterling will also have an adverse impact on beef prices in Ireland which are forecast to decline by 12%.
Overall, the increase in profitability in the dairy sector in 2017 is forecast to be sufficient to offset a significant decline in beef farm income, leaving overall agricultural income in Ireland about 5% higher in 2017.

AVTRW hosts 50th Scientific Meeting



Pictured at the 50th Annual Scientific Meeting of the Irish Branch of the Association of Veterinary Teaching and Research Work (AVTRW) are (from left): Bryan Markey, UCD and President of the AVTRW (Irish branch); Peter Nettleton, Moredun; and Kieran Meade, Teagasc and secretary of the AVTRW (Irish branch).

Kieran Meade,
Senior Animal Health Bioscientist,
Teagasc Animal & Grassland Research and Innovation Centre,
Grange,
Co Meath

Correspondence:
kieran.meade@teagasc.ie

The special anniversary 50th Annual Scientific Meeting of the Irish Branch of the Association of Veterinary Teaching and Research Work (AVTRW) was held in October in the Clinton auditorium, University College Dublin (UCD). In recognition of the anniversary, this year marked a special joint meeting between the parent and Irish branches of the AVTRW.

Newly appointed Dean of Veterinary Medicine in UCD, Michael Doherty, opened proceedings and referred to his fond memories of giving his first talk as a graduate student at the AVTRW conference. In conjunction with Veterinary Ireland, the talks opened with a perspective on veterinary nursing education and on the legislative framework surrounding the use of non-rodent models for teaching and research from the Health Products Regulatory Authority (HPRA).

Virology in focus

The Animal Health theme for the day was particularly orientated towards virology. Three keynote speakers addressed the AVTRW meeting: Louise Cosby, newly appointed head of virology at the Agri-Food & Biosciences Institute (AFBI), on the 'Challenges of current virus threats to animal health and strategies for prevention and control'; Peter Nettleton, Moredun Research Institute, gave an exciting summary spanning '50 years of virology: from Arboviruses to Zika going viral'; and Martin Green, from Nottingham University, talked about his research, 'Udders and uncertainty: adventures in the control of bovine mastitis'. In addition there were a further 11 scientific talks and a comprehensive poster session with 24 posters. Martin Green was presented with the AVTRW Selbourne award for his contribution to veterinary research.

The session closed with an excellent review of the Animal Health Ireland (AHI) cattle disease control programmes by David Graham. Talks were sponsored by the British Society for Animal Science, the parent body of the AVTRW, and by the Department of Agriculture, Food and the Marine (DAFM). Additional sponsorship was kindly provided by Teagasc and Bio-sciences.

Networking opportunities

The meeting provided a useful networking opportunity for veterinary and animal health researchers from all over the island, including postgraduate students and staff from AFBI, the Department of Agriculture, Environment and Rural Affairs, Queen's University Belfast (QUB), DAFM, Teagasc, UCD, Trinity College Dublin, AHI and Animal Health and Welfare Northern Ireland in addition to academics and researchers from the UK.

The AVTRW student awards were presented to Amy Brewer, Teagasc, for her poster on 'Defining the inflammatory signature associated with bovine endometritis' and to Dagmara Niedziela, Teagasc, for her presentation entitled 'Lineage specific differences in host cell internalisation and immune response to bovine adapted *Staphylococcus aureus*'.

For information on next years meeting, please contact kieran.meade@teagasc.ie

The role of IP in

Miriam Walsh, Teagasc Technology Transfer Office, gives an overview of the Government's goals in its new strategy for research and development, science and technology, in relation to impact on intellectual property (IP) management and technology-transfer functions within research performing organisations such as Teagasc.

Miriam Walsh,
Head of Intellectual Property, Teagasc

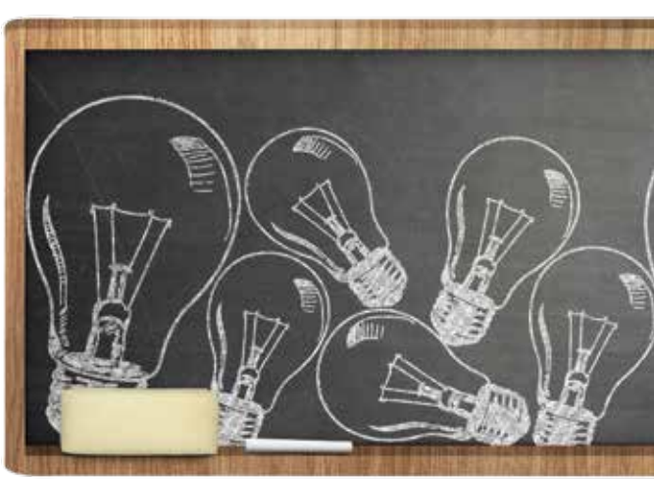
Correspondence:
miriam.walsh@teagasc.ie

Innovation 2020, Ireland's new strategy for research and development, science and technology, was launched in 2015. In the strategy, the Government outlines its aims to build on the significant progress made to date in developing Ireland's research and innovation system, by continuing to support excellent research. The document states that Ireland's vision to be a global innovation leader must be underpinned by the following goals: excellent research in strategically important areas, with relevance and impact for the economy and society; an internationally-competitive research system; a strong innovative and internationally-competitive enterprise base; a renowned pool of talent in Ireland's public research system and industry; and a coherent innovation ecosystem, responsive to emerging opportunities.

The role of IP in innovation

Under the umbrella of a coherent innovation ecosystem, and in terms of supporting innovation through protection and transfer of knowledge, an effective regulatory framework for protecting IP was identified as key. Innovation 2020 emphasises the critical role of IP in supporting innovation, through promoting the commercialisation of products from publicly-funded research, and assisting enterprises to use IP to increase innovation levels and competitive advantage. According to the strategy: "A fit-for-purpose IP regime acts as an important driver of innovation, leading to economic and employment growth."

Optimising the transfer of knowledge from public research to enterprise has been central to Government strategy for a number of years. In 2007, the Technology Transfer Strengthening Initiative (TTSI) was established as a national programme to support research performing organisation (RPO) technology transfer offices (TTOs), in terms of expertise provision and funding. Further initiatives include the introduction of the first National IP Protocol in 2012, which provided a framework for industry-academic collaboration, and the establishment of a central technology transfer function to support RPO TTOs; whose roles are to facilitate and support technology transfer and IP commercialisation from RPOs to industry. This led to the establishment of Knowledge Transfer Ireland (KTI) in 2013 as a partnership between Enterprise Ireland and the Irish Universities Association; its role is to ensure businesses benefit from access to Irish expertise and technology by making it easier to connect and engage with the research base and RPO TTOs in Ireland and, since 2013, it coordinates the TTSI. Over €50 million has been invested in Ireland's public technology transfer infrastructure through the TTSI, with Teagasc TTO benefitting from such support since 2013, through a consortium (with UCC and Cork IT TTOs).



Innovation 2020 commitments

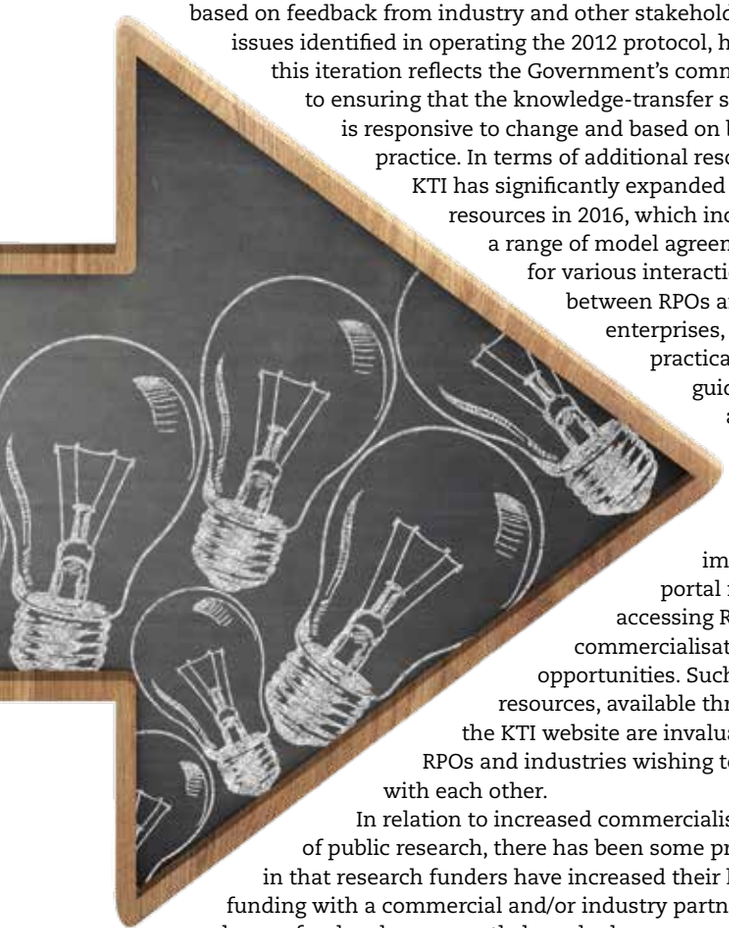
Despite significant progress prior to 2015, the need for long-term commitment is emphasised in Innovation 2020. Commitments made to benefit knowledge transfer between public research and enterprises include the establishment of a revised IP protocol and additional resources at a national level to promote further engagement between public research to enterprises. This includes another phase of TTSI funding for TTOs from 2017. Furthermore, the need to encourage increased commercialisation of

driving innovation

publicly-funded research, and develop new impact metrics focusing on quality, for commercialisation are outlined as key actions. Other actions are also addressed, but with a focus on supporting innovation in the enterprise base.

Developments within Innovation 2020

Since 2015, many commitments made by the Government have been realised. Firstly, in terms of strengthening knowledge transfer, 'Inspiring Partnerships – the 2016 National IP Protocol' was launched in 2016, representing an update and improvement to the 2012 protocol. It sets out Government's policies to encourage industry to benefit from publicly-supported research, and goes a step further in terms of rules and recommendations. Such revisions were based on feedback from industry and other stakeholders on issues identified in operating the 2012 protocol, hence this iteration reflects the Government's commitment to ensuring that the knowledge-transfer system is responsive to change and based on best practice. In terms of additional resources, KTI has significantly expanded such resources in 2016, which include a range of model agreements for various interactions between RPOs and enterprises, practical guidelines and an improved portal for accessing RPOs' commercialisation opportunities. Such resources, available through the KTI website are invaluable for RPOs and industries wishing to engage with each other.



In relation to increased commercialisation of public research, there has been some progress in that research funders have increased their level of funding with a commercial and/or industry partner focus; and some funders have recently launched new programmes in this space. As well as access to such funding at a national level, it is equally important that RPO researchers are encouraged and incentivised within their organisations to increase their level of such funding and involvement in commercialisation.

Regarding new targets for commercialisation of research, a timeline of 2017 was set, in alignment with the commencement of TTSI3. The call for TTSI3 funding was made in 2016 and Teagasc, with consortium partners UCC, Cork IT and IT Tralee, have secured five years of support for their TTOs from 2017. Throughout TTSI2 (2013-2016) a requirement of RPO TTOs has been to track, report on, and indeed strive to achieve challenging technology transfer metrics, including patents, inventions, licenses and spin-out numbers – all focused on quantity.

Participation in TTSI3 programme, however, will involve taking on measurement of, and commitment to achieve, specific targets of more complex metrics associated with quality. Examples include conversion rates of patents to licences and income generated from licences. The result should be a more complete picture of the impact of research through technology transfer by focusing on quality and quantity of outputs. Such performance-based reports should highlight the significant impact of publically supported research in terms of return on investment through subsequent technology transfer to industry, which benefits the industry, the RPOs and the economy.

Summary

The focus on IP in supporting innovation through Government strategy continues to benefit RPOs, in terms of additional resources, tools and capabilities for their TTOs and added visibility of their capabilities to enterprises. Also, the TTSI3 programme confirms the Government's commitment in supporting RPO TTOs in their roles as facilitators of technology transfer and IP commercialisation. This has led to additional reporting obligations for the RPO TTOs, in terms of technology transfer metrics, as well as challenging targets to achieve, which the researchers and relevant research programmes need to be aware of, given their contribution is central to effective technology transfer. Key drivers in securing maximum benefit to industries in terms of accessing RPO IP, which RPOs can influence, include: increased awareness of RPO researchers in such nationally-driven objectives and key performance indicators in technology transfer; further incentivisation of researchers in technology transfer; and adequate resourcing and positioning of technology transfer functions within the research support ecosystem of RPOs.

References

[DJEI], Department of Jobs, Enterprise & Innovation. (2015) 'Innovation 2020-Ireland's strategy for research, development, science and technology'.

[DJEI], Department of Jobs, Enterprise & Innovation. (2012) 'Putting Public Research to Work for Ireland', June 2012. Available online: www.knowledgetransferireland.com

[DJEI], Department of Jobs, Enterprise & Innovation. (2016) 'Inspiring Partnerships-National IP Protocol. Policies and resources to help industry make good use of public research in Ireland'.

Pupils from Crossabeg National School visited Teagasc Crops, Environment and Land Use Research Centre, Johnstown Castle, Wexford to see researchers' grass trials in conjunction with their own grass trials for the upcoming BT Young Scientist and Technology competition. Pictured (from left) are: Karen Daly, Teagasc Research Officer; Pierce Doyle; Rebecca Quinn; and Rachel Meeney.

Science Week

Festival of Farming and Food

For Science Week 2016, Teagasc hosted one of 11 Science Foundation Ireland-supported Science Week Festivals – the 'Festival of Farming & Food'.

Catriona Boyle,
Science Communications and Outreach,
Teagasc Head Office

Correspondence:
catriona.boyle@teagasc.ie

For Science Week 2016, Teagasc hosted the 'Festival of Farming & Food', one of 11 Science Foundation Ireland-supported Science Week Festivals. Teagasc research centres invited local schools and members of the public to learn about the work Teagasc does in science-based innovation in agriculture and food, using new technologies in plant and animal genomics, food processing and precision agriculture.

This year's Science Week theme was 'Science Rising' – focusing on the progression of scientific technologies over the last 100 years in agriculture, food processing, nutrition, and food safety. Teagasc centres explored how traditional methods of the agri-food industry have developed over time, and showcased the current technologies used in agri-food research.

Science Week events at Teagasc Centres

Teagasc Animal & Grassland, Research and Innovation Centre in Grange, Co Meath hosted two open days. Primary-level students from the Trinity Access Programme visited the centre for a tour of the labs and farm for the '**Your Food Starts Here**' event. A second open day was aimed at second-level students in the locality.

Understanding the Irish Dairy Industry at Teagasc, Moorepark, Co Cork gave local secondary students the opportunity to use microscopic tools in the Food Research centre, and to see some of the key technologies that underpin dairy farming in the Animal & Grassland, Research and Innovation Centre, including a tour of the research lab. They also got an opportunity to see the animals on the farm.

In the Teagasc Moorepark Food Research Centre, students learnt about how microbiology and food safety have progressed, and saw how food microstructure relates to the food experience in the microscopy lab. Students also got to walk through a gut simulation – showing them the different processes that take place during digestion.

So that's DNA! Ryan Lehainn, Scoil Eoin Kilbarrack from the Trinity Access Programme gets a closer look at a DNA extract at Teagasc Animal and Grassland Research and Innovation Centre, Grange, Co Meath.

Daniel Grummel and Mickey Lynch from O'Hara's (Carlow Brewing Company) spoke to third-level students about the science behind the perfect pint at Teagasc Crops, Environment and Land Use Research Centre in Oak Park, Carlow.

Katie Long from the Presentation College, Athenry, looks at some parasites at Teagasc Animal and Grassland Research and Innovation Centre, Athenry, Co Galway.

Second-level students in Galway visited the Teagasc Animal & Grassland, Research and Innovation Centre, Athenry, Co Galway. There they were given an insight into how science is being used to address reproduction and parasitism issues in sheep. Students got to meet different sheep breeds and learn about their attributes and role in Irish farming. They took part in interactive exhibits to learn about different grass and clover species and nitrogen fixation, as well as hearing about career options in the agri-food industry.

Teagasc Crops, Environment and Land Use Research Centre in Oak Park, Carlow, hosted **From Barley to Beer – The Science of the Perfect Pint**. Students from Pearse College, Dublin and postgraduates from Carlow IT were given a demonstration of the malting process by a local maltster from Boortmalt and a beer brewing demonstration and tasting by a senior brewer from O'Hara's, a local brewing company. Oak Park researchers also demonstrated precision farming.

Teagasc Food Research Centre in Ashtown, Dublin 15, held **A Taste of Food Science,** a free evening event open to the general public (see article on page 12.)

At Teagasc Crops, Environment and Land Use Research Centre, Johnstown Castle, Wexford students from local primary schools learnt about grass trials.

Other Science Week initiatives

Other Science Week initiatives by Teagasc included the annual Teagasc Walsh Fellowship Seminar at the RDS, Dublin.

At **Rustic by Dylan McGrath, Dublin**, Orla O'Sullivan, a Senior Research Fellow in Teagasc Food Research Centre, and Ruairi Robertson and Elaine Patterson, Alimentary Pharmabiotic Centre, were among the special guests joining celebrity chef Dylan.

Teagasc researchers took part in **I'm a Scientist, Get me out of Here!** Karen Foley from Teagasc Moorepark and Catherine Keena from Kildalton College formed part of the panel of scientists in this (Farming Zone) live online discussion. See: www.imascientist.ie

Kerry Science Week - The Science behind Forestry for second and third level students: Teagasc Forestry Development Officer Tom Houlihan highlighted developments in forestry as part of Kerry Science Week.

Cavan and Monaghan Science Festival: Ballyhaise Agricultural College, which is run by Teagasc, participated in the Cavan and Monaghan Science Festival in partnership with Cavan Library Service.

Andre Brodkorb from Teagasc Food Research Centre in Moorepark and Stuart Green, Rural Economy and Development Programme featured in a series of books called **Science Apprentice,** free with the *Irish Independent* in Tesco stores.

Acknowledgments

The contribution of the many staff and students to the successful running of Teagasc Science Week events is greatly appreciated.

Julie O'Sullivan, Teagasc, Moorepark, showing Colaiste an Chraoibhin, Fermoy students a gut simulation.

A taste of food science

Measuring the crunchiness of biscuits with Eimear Gallager and Kim Millar at the bakery stand.

Teagasc held a public open evening at its Food Research Centre in Ashtown, Dublin, during Science Foundation Ireland's Science Week.

How do we use all our senses to relate to food? How are sausages made? How clean are your hands? What makes a good steak? What exactly is gluten? What did our medieval ancestors eat? What's the carbon footprint of the Irish diet? Do you know what food labels mean? The answers to these and many more questions were addressed at 'A Taste of Food Science' at Teagasc Ashtown Research Centre during Science Week. This event was one of Teagasc's events organised for the 'Festival of Farming & Food – Science Week at Teagasc', in association with Science Foundation Ireland.

Catriona Boyle,
Science Communications and Outreach,
Teagasc Head Office
Maire Caffrey,
Teagasc Head Librarian

Correspondence:
maire.caffrey@teagasc.ie

Sensory analysis in action

Carol Griffin, Carmel Farrell and Chris Ovenden set the scene for an interactive demonstration of how our senses work in tandem to enhance our eating experience. Visitors were challenged to identify the five basic tastes (salt, sweet, bitter, sour and umami) with a series of clear solutions. Participants also found the exercise of tasting a range of clear liquids of various different, unusual flavours to be more difficult than they at first would have imagined. The absence of colour, meant a key clue as to the liquid's flavours was missing. This simple test along with a few others on the night illustrated to the interested public, the necessary interaction of all our senses in enhancing our eating experiences. A few quite sensitive tasters were able to distinguish between a series of flavoured jellies (orange, lime, strawberry and lemon) – all coloured red to trick the senses.

Two groups of attendees were also selected to take part in formal consumer trials on several food products. These were regular consumers of the products and provided valuable insights for product development studies being carried out by Food Industry Development Department personnel.

Sensory science

Eating is among the most pleasurable and multisensory experiences in our everyday lives. However, people don't often realise that the satisfying sensations they perceive while eating are derived from a complex multisensory interaction between each of the five senses – sight, smell, touch, taste and hearing. At the 'A Taste for Food Science' event, Emily Crofton presented to the public on how our flavour experiences and enjoyment of food can be enhanced by stimulating all of our senses. "Flavour perception is not simply about how the food tastes on the tongue. For example, the colour of cooked steak provides critical information as to its texture and edibility, while the sound we hear when biting into a crisp contributes to our perception of its crispiness and freshness. Our brain processes and interprets the information from each sensory input evoking a flavour sensation," explains Emily. Sensory science is increasingly being used by food and drink companies for designing innovative, multisensory products that effectively stimulate all five senses, delivering new eating and drinking experiences to consumers.

Emily Crofton delivered a talk on the complex multisensory experience involved in our enjoyment of food.

Cereal and bakery research

The topic of gluten and gluten-free diets continues to receive significant attention from the media, and many scientific groups are endeavouring in their research in this area. Scientist Eimear Gallagher explains: "Gluten is a 'structure-building' protein found in wheat, barley and rye, and is an integral constituent for the baking process, and in particular, for breadmaking. Its absence leads to a breakdown of dough elasticity and inferior bread structure, texture and eating quality." Ingredients, which have been used to replace gluten include starches, hydrocolloids, alternative proteins and enzymes, and due to extensive research and innovation activities, the quality of gluten-free products has improved greatly. At the cereal science and bakery stand, attendees were able to see what pure gluten looks like, and were given the opportunity to stretch a sample of it, and witness its very elastic properties. Wheat dough and gluten-free dough were also presented, along with a range of alternative grains and flours that can be used in gluten-free formulations. Attendees were also presented with some laboratory testing equipment that is commonly used to analyse the texture of bakery products. They were shown how to use the equipment to measure the crunchy properties of a range of different types of biscuits.

The science behind the perfect steak

The 'Perfect Steak' stand provided visitors with the latest information on what factors are most influential in providing optimal tenderness, flavour and juiciness. A key point of interest was in understanding that, while on-farm or animal level factors are influential on tenderness, the main interventions to improve this trait happen after slaughter. In particular, the early post-mortem handling of carcasses (e.g., chilling regime, method of hanging) is critical, while the length of post-mortem ageing is also important. Conventional and innovative packaging systems were discussed and some common myths relating to meat colour and fat were clarified. In addition to presenting an overview of different types of cuts and their associated quality characteristics, the relevance and scientific basis for different cooking methods were discussed. Researcher Anne Maria Mullen explains: "The method used to cook meat has an important influence on tenderness, with meat containing more connective tissue requiring a longer, lower temperature cooking process than, for example, a prime striploin steak, which benefits from short, high-temperature cooking. Particular interest was expressed in a cooking guideline for achieving the correct level of 'doneness' for the perfect steak."

Ash Dieback disease

Chalara Disease (Ash Dieback) is a serious threat to our native ash trees, which could in turn endanger the age-old craft of making hurleys. Gerry Douglas explained how Irish researchers are working to save our precious ash trees using DNA markers and hybrid breeding programmes: "The number of confirmed cases of Ash Dieback disease (Chalara) has increased despite major efforts to eradicate the fungus, which causes the death of shoots and, after several years, can kill trees. Ash dieback is spread by fungal spores that travel on the air from near and far." Species of ash from Asia are naturally resistant to dieback disease and Teagasc is attempting to cross them with Irish ash as a first step to transfer the resistance into our native ash. "A very small proportion of trees in our native population of ash trees will prove resistant and we can use them for vegetative propagation and also as a basis for breeding and producing resistant seeds," says Gerry. Research in Teagasc aims to identify resistant trees and develop the most efficient means to make available resistant plant material for the future.

Carmel Farrell and Carol Griffin (pcitured) carried out taste tests with a new high protein yoghurt (ProU).

Paul Allen and Anne Maria Mullen at the meat stand discussing what makes the perfect steak with a visitor.

Gerry Douglas talks about Ash Dieback with some young visitors.

Acknowledgments

Well done to all the Teagasc staff and students who contributed to the success of Science Week events and other initiatives this November. Teagasc ran one of 11 Science Foundation Ireland-supported Science Week Festivals – the 'Festival of Farming and Food' at a number of venues around the country. A video from 'A Taste of Food Science' can be found on the Teagasc Media YouTube channel.

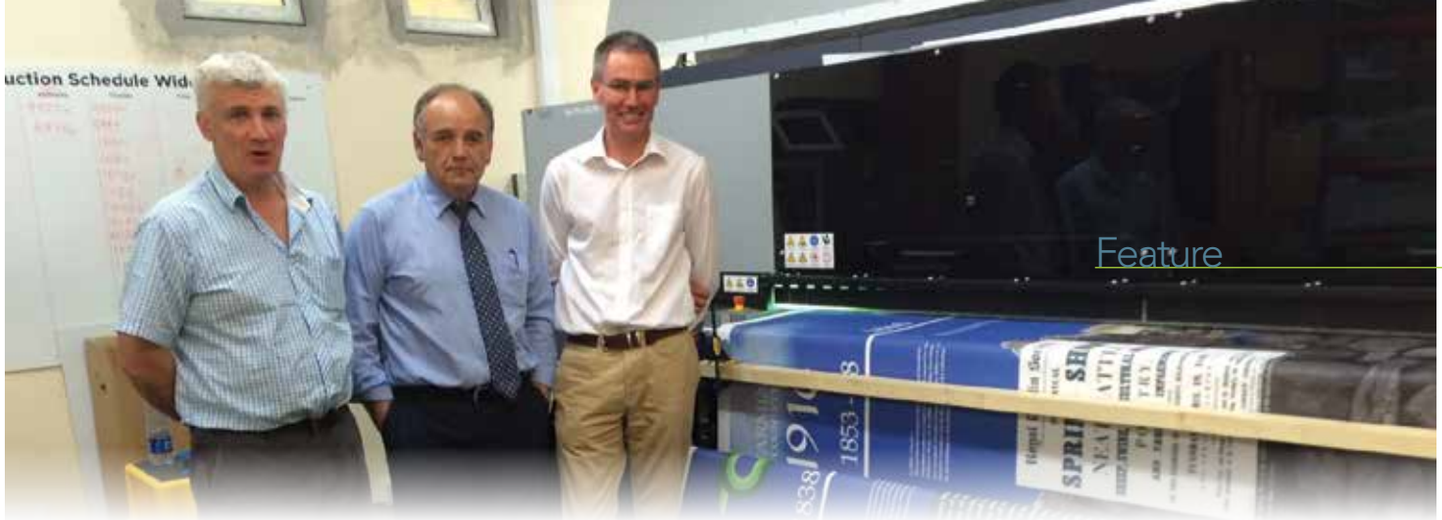
Farming and country life 1916 – reflections in stone

Larry O'Loughlin,
Regional Manager
Education and Advisory
Services, Teagasc
Eoin Sullivan,
Director,
Gort Archaeology

Correspondence:
gortarchaeology@gmail.com

As the centenary year of 1916 draws to a close, countless citizens and overseas visitors who seized the opportunity to partake in the many commemorative events, can now and in the future reflect on the significance of the events they experienced. Teagasc marked the centenary with its own event in Athenry, which was the largest 1916 Commemoration event outside Dublin.

The flagship two-day event, which took place in Teagasc's Mellows Campus, Athenry, Galway, was organised by Teagasc in conjunction with a multitude of national, regional and local organisations, entities and people. Reflecting the scope of the brief – to enable people experience and appreciate farming and country life in 1916 – required the formation of several intertwined thematic villages. One of these villages, *Agricultural Education and Co-operatives*, presented a range of individual organisational exhibits. A unique backdrop of a printed pictorial wall traced the collective heritage of these organisations in the context of milestones in the development of agriculture in Ireland.



Cathal MacCarthy, ICMSA; Larry O'Loughlin, Teagasc; and Eoin Sullivan, Gort Archaeology, at the production stage of the chronological timeline

The chronological timeline

From the outset, Larry O'Loughlin, Regional Manager Education and Advisory Services, Teagasc, and Chairman of the Agricultural Education and Co-operatives village, proposed the creation of a chronological timeline that would embody a sense of place within Mellows Campus, which was the chosen venue for the event. It was agreed that this would encourage visitors to take their time to learn about the heritage of the organisations involved in the day-to-day running of agriculture in Ireland in 1916.

The challenge faced by the participating organisations was to agree the parameters of the timeline. The event was focused on 1916, but the context of the event, in terms of the heritage of agricultural education and co-operatives, demanded a multi-faceted perspective. Without such a vision, the village participants would not have been able to show the interconnectedness of their organisations and present the story of their involvement in the build-up, events and knock-on effects of 1916.

Eoin Sullivan, Gort Archaeology, designed the village's chronological wall, creating a sense of place for visitors at the Mellows Campus that was in keeping with the wider region of Co Galway. This was encapsulated in the traditional stone wall, with the discrete blocks of texts for relevant years associated with key events for the organisations involved.

The 25m-long chronological wall was a digitally printed canvas that was attached to a wooden, purpose-built frame in the Village exhibition space. It consisted of a series of period-based photographs and illustrations, with explanatory text included. The digital creation was edited and produced by Paul O'Grady and his team at Think Media.

The foundation stone

The wall told the story of developments in agriculture and their impacts on the different members of the farming sector. The foundation stone in the construction of the wall was the collegial working relationships between all organisations who volunteered to send representatives to participate in the event. The organisations involved, namely Teagasc, the Department of Agriculture, Food and Marine (DAFM), the Irish Farmers Association, University College Dublin, the Irish Co-operative Organisation Society, Macra na Feirme, the Irish Cattle and Sheep Farmers Association, the Irish Creamery Milk Suppliers Association and the Royal Dublin Society, compiled relevant materials from their archives, existing exhibitions (DAFM's travelling 1916 Exhibition) and published materials for incorporation on the chronological wall.

The chronological wall acknowledged the role played by the County Committees of Agriculture (established in 1898), which were coordinated by the Department of Agriculture and Technical Instruction. The County Committees kept detailed minutes of the day-to-day organisation and running of courses delivered by the itinerant instructors, until the formation An Chomhairle Oiliúna Talmhaíochta (ACOT) in 1980, which had responsibility for agricultural education and advice. A new agricultural research institute, An Foras Taluntais, formed in 1958, and amalgamated with ACOT 30 years later, resulting in the establishment of Teagasc. The Teagasc model of integrated research, advisory services and education is unique to Ireland. The merits of this model have been seen internationally with some countries moving towards achieving similar synergy.

A positive response

A steady flow of people of all ages, interests and rural backgrounds processed past the chronological wall during the event. Visitors were inquisitive and interested in the insights that could be gleaned about the development of the different agricultural organisations. The chronological wall provided a backdrop for the representatives from the participating organisations. Their representatives were available at individual stands to answer queries about their organisation and the many fascinating social artefacts on display, including the college bench from Albert College, Dublin, the County Agriculture Committee Minute Books, and the butter churn, as well as the re-enactment of an evening class in a local hall giving instruction in potato spraying and egg storage.

The wall was subsequently exhibited at different agricultural events in Ireland in 2016, including the Tullamore Show and the Virginia Show, which is a clear indication of the success of the exhibit. Versions of the chronological wall, with a reduced content and scale, are being put on permanent display at the Teagasc education centres around the country. The stone walls of Athenry and the stories they tell will live in the mind's eye of the next generation of farmers as they receive instruction and graduate from their agricultural establishments.

Development of the Teagasc Lamb Production Model

Alan Bohan,
Walsh fellow PhD candidate, Teagasc and University College Dublin
Laurence Shalloo,
Senior Research Officer,
Nóirín McHugh,
Research Officer,
Teagasc Animal and Bioscience Research Department, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co Cork

Correspondence:
alan.bohan@teagasc.ie

A full-farm system bio-economic model was developed for the Irish sheep industry and is applied here to assess the effect of stocking rate and ewe prolificacy on farm profit.

Farm system modelling is increasingly used in research to provide a greater understanding of the factors that determine farm profitability. Bio-economic models are capable of simultaneously assessing the biological and economical aspects of a farm system, and are used extensively in Teagasc dairy and beef research to guide research priorities. Until the development of the Teagasc Lamb Production Model (TLPM), however, no such tool was available to the Irish sheep industry. This article describes the development and validation of the new sheep model, and illustrates the usefulness of the model for addressing pertinent industry questions.

Model development

The TLPM is a whole-farm, bio-economic simulation model that calculates the physical, financial and economic outputs of an Irish sheep farm. The sheep model is capable of simulating institutional, technical and economic change; and assesses the resulting effects on farm productivity and profitability (e.g., stocking rate). The model was built using real Irish farm data from multiple sources, including the Teagasc BETTER farm programme, Athenry research data and input from industry experts. The model simulates the annual production cycle of a sheep flock; commencing at mating. The energy requirements for the flock are calculated on a monthly basis, allowing a monthly feed budget to be derived; this varies by stage of production and time of year. The sheep model is stochastic, meaning that key inputs can be included as distributions of values rather than point estimates (e.g., lamb mortality, concentrate price and lamb price), thus reflecting real-life, year-to-year variability.

Biological inputs, including farm size, animal numbers and valuations, pregnancy scanning rate and lambing date, are used to calculate the physical and financial outputs. The key economic outputs are annual cashflow, profit and loss account and a balance sheet; and key physical outputs are feed supply and demand, livestock trading schedule and physical ratios, such as the amount of concentrate fed and number of lambs slaughtered. Net profit is presented on a total farm basis, as well as per hectare, per ewe joined, per lamb slaughtered and per kg of carcass sold.

Model validation

A robust validation of any bio-economic model is required to ensure the model provides a useful, realistic and accurate tool for future research. The sheep model was validated by comparing model outputs with real farm data from the Teagasc e-Profit Monitor (EPM). This validation approach involved the simulation of the average performance of 20 commercial sheep farms from the EPM to the simulated physical and economic outputs from the TLPM. The model was set to the same farm size (42ha), stocking rate (9.46 ewes/ha) and weaning rate (1.42 lambs per ewe joined) as the average of the 20 EPM farms. Results from the validation demonstrated that the model closely simulated the EPM farms with similar total receipts (€1,220/ha vs. €1,303/ha), total farm costs (€916/ha vs. €1,057/ha) and net profit figures (€263/ha vs. €234/ha), indicating that the model provides a true representation of the performance of a typical Irish sheep farm.

Model application

After successful validation of the model, applications of the model can be explored. Potential applications include assessing the effect of biological, economical and technical system changes on farm profitability. Stocking rate and ewe prolificacy have been described as two of the key drivers of profitability for Irish lowland, mid-season lambing flocks; however, their economic impact has not been reported. Therefore, the sheep model was used to assess the effect of stocking rate and ewe prolificacy on farm profitability. The model simulated three farm scenarios with varying stocking rate and prolificacy potentials: a national average, low-output flock (7.5 ewes/ha weaning 1.3 lambs per ewe joined); a medium-output flock (10 ewes/ha weaning 1.5 lambs per ewe joined); and a high-output flock (12 ewes/ha weaning 1.8 lambs per ewe joined). Each scenario operated a grass-based system with the majority of lambs finished off-grass. The greater stocking rate and number of lambs weaned per hectare were accounted for by growing and utilising more grass and a slight increase in concentrate supplementation.

The three stocking rate and prolificacy levels resulted in flock sizes of 150 ewes (195 lambs [10 lambs/ha]), 200 ewes (300 lambs [15 lambs/ha]) and 240 ewes (432 lambs [22 lambs/ha]) weaned for the low-, medium- and high-output flocks, respectively (Figure 1). The low-output flock sold eight lambs per hectare (167kg/ha), whereas the medium-output flock sold 13 lambs per hectare (255kg/ha) and the high-output flock sold 19 lambs per hectare (364kg/ha); for the high-output flock this equated to an additional 197kg (117%) produced compared to the low-output flock.

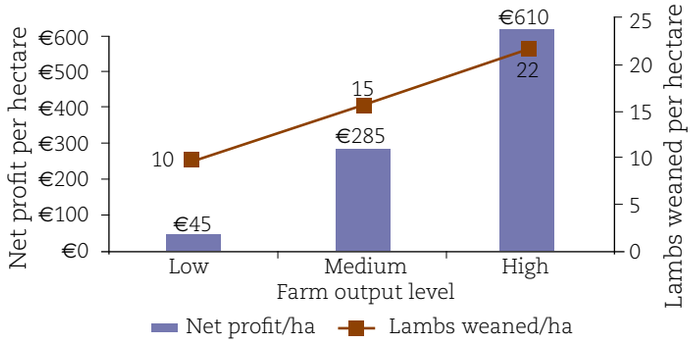


Figure 1. The effect of lambs weaned per hectare on net profit.

The lamb receipts for the low-, medium- and high-output scenarios were €785/ha, €1,200/ha and €1,695/ha, respectively. Due to the greater demand for grass in the higher stocked scenarios, the fertilizer costs increased from €148/ha in the low-output scenario to €269/ha in the high-output scenario. After accounting for all the costs of production, excluding labour, the net profit was €45/ha, €285/ha and €610/ha for the low-, medium- and high-output scenarios, respectively (Figure 1).

Increasing the number of lambs weaned per hectare reduced the cost of production per carcass from €102 in the low scenario to €68 in the high-output scenario. It was assumed in the model that the higher-output scenarios grew and utilised more grass. It should be noted, however, that sensitivity analysis showed that increasing the number of lambs weaned per hectare without increasing grass growth and utilisation resulted in a negative net profit figure.

Future uses of the TLPM

The TLPM provides an important modelling tool for the Irish sheep sector, and will continue to be used to address pertinent industry questions with the aim of directing future research and farm management to improve the profitability of the national sheep industry. In addition, the TLPM will also be used to calculate economic values for use in national sheep genetic evaluation programmes. Finally, the TLPM will provide a means of adding an economic component to future sheep systems research.

Acknowledgements

This research was funded through the Teagasc Walsh Fellowship Scheme.

Assessing land-drainage performance

Pat Tuohy,
Heavy Soils Programme, Teagasc Animal and Grassland Research and Innovation Programme, Moorepark
Owen Fenton,
Teagasc Crops, Environment and Land Use Programme, Johnstown Castle

Correspondence:
patrick.tuohy@teagasc.ie

Mole drainage is used in fine, poorly-permeable soils, in conjunction with a network of shallow field drains, to improve hydraulic conductivity, thereby, increasing infiltration of rainwater to the field-drainage system.

In such soils, the installation of field drains alone does not offer sufficient discharge capacity. Mole drainage relies on a network of closely-spaced channels and subsoil cracks, formed during installation, to rapidly discharge excess soil water during rainfall events (Tuohy *et al*, 2016). Stable mole channels can only be formed in clay-textured, stone-free soil layers and their performance and lifespan will be largely dictated by soil type and installation conditions (particularly soil-moisture content during installation). Their lifespan can vary from one to five years.

Monitoring system performance

The performance of a mole drainage system, installed in Doonbeg, Co Clare, is being monitored as part of the Teagasc Heavy Soils Programme. Soil physical and modelled hydraulic parameters for the site are presented in Table 1. In June 2013, a series of field drains were installed at a depth of 0.9m and spacing of 15m, comprising of 110mm corrugated pipe and stone aggregate (10-50mm grade) backfilled to within 0.2m of the soil surface. Mole drains were installed perpendicular to these drains at a depth of 0.6m and spacing of 1.4m.

End-of-pipe flow-meters record water-flow rates, while a number of in-field wells (2m deep) with water level sensors record water-table fluctuations. There is also a weather station on the farm.

Table 1. Soil physical and hydraulic parameters. θ_r = residual water content, θ_s = saturated water content, ks = saturated hydraulic conductivity.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Dry density (g/cm³)	Bulk density (g/cm3)	θ_r (cm³ cm⁻³)	θ_s (cm³ cm⁻³)	k_s (m/s)
0-26	21	45	34	1.11	1.61	0.078	0.390	3.52E-07
26-47	13	49	38	1.23	1.73	0.077	0.370	1.75E-07
47-75*	12	59	29	1.65	2.04	0.053	0.288	6.73E-08
75-140	23	50	27	-	-	0.078	0.441	1.47E-06

**Mole drain channels installed in this layer.*

Simulation models

Using modelling software, it is possible to create a simulation of the drainage system installed. This simulation can then be manipulated to estimate the performance of the installed system (or alternative system designs) in a range of hypothetical short and long-term weather events. The key input parameters for the modelling software include soil physical characteristics, drainage design and weather conditions. The SEEP/W software package developed by GEO-SLOPE (2012) was used in this study.

The project had three objectives: i) to model the performance of a combined field/mole drainage system during a short-term, high-intensity rainfall event using SEEP/W software; ii) to validate the model and assess its reliability relative to measured discharge collected over a three-month period; and iii) to model the installed system and a range of alternative systems under a range of rainfall scenarios to assess their performance.

Model calibration and validation

The model was calibrated by simulating an actual rainfall event (Event A), which occurred over a five-day period spanning September 10-15, 2015. During this period, 156.4mm of rainfall was recorded on the farm. The material properties of soils below the mole channels were defined using data from the site-soil survey and hydraulic properties derived from them (Table 1). Above the mole channels, soil properties could be varied to model improved hydraulic properties brought about by mole drainage. The field drain was assigned a high-saturated hydraulic conductivity (k_s = 10m/s), while mole drains were assigned a k_s of 0.001m/s. Analyses were run with a range of values assigned for k_s above the mole channel until the drain discharge results in the model output were comparable to the field results observed. The resulting modelled drainage system is referred to as System 1 with soil k_s above the mole channel of 5.50cm/hr. A dataset spanning a three-month period from October 1 to December 31, 2015 (Event B) was used to validate the model formulated. The modelling software provided reliable predictions of drain discharge of a combined field/mole drainage system compared with actual values (Figure 1).

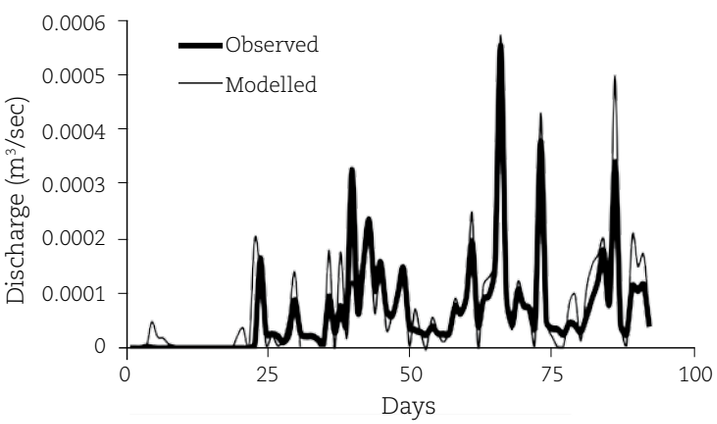


Figure 1. Comparison of daily field drain discharge from modelled analysis and observed field measurements of installed drainage system (System 1) during Event B.

Modelled alternative systems

Three alternative drainage systems were evaluated under the conditions of both rainfall events, i.e., the calibration event (Event A: September 10-15, 2015) and the validation event (Event B: October 1- December 31, 2015). System 2 consisted of field drains only with no mole drains. System 3 and 4 are similar to System 1 except soil k_s above the mole channel has been set at 0.55cm/hr and 55.00cm/hr, respectively, equivalent to the calibrated k_s in System 1 divided or multiplied by a factor of 10 to mimic either a reduction or improvement in mole-channel integrity. Furthermore, simulations were carried out for two hypothetical rainfall scenarios. In Event C, a rainfall rate of 2mm/h was applied to all systems for 50 hours. In Event D, the 30-year average daily values were applied to all systems.

Assessing system performance

Systems 1 and 4 consistently outperformed Systems 2 and 3 in terms of average and peak discharge and water-table control capacity. Across rainfall events, System 2 (without mole drains) was the least effective, and reduced drain discharge (Figure 2) and average water-table depth when compared with Systems 1 and 4. The performance of combined field/mole drainage systems reflected the variations in k_s of that material above the mole channels. The greater the improvement in soil k_s brought about during mole channel installation, the better the system performance will be.

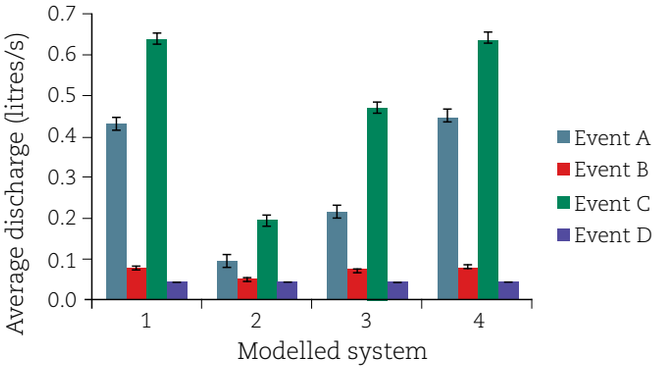


Figure 2. Comparison of mean field-drain discharge from modelled drainage systems; (1) Installed system (field drains with mole drains), (2) Field drains only, (3) Installed system with deteriorated mole drains, (4) Installed system with improved mole drains.

References

GEO-SLOPE (2012). SEEP/W, Version 8.0.10.6504. Calgary, Canada: GEO-SLOPE

Tuohy, P., Humphreys, J., Holden, N.M. and Fenton, O. (2016). 'Runoff and subsurface drain response from mole and gravel mole drainage across episodic rainfall events'. *Agricultural Water Management*, 169: 129-139.

Targeting agricultural-runoff hotspots

Ian Thomas
Walsh Fellow, Teagasc Agricultural Catchments Programme, Johnstown Castle, Co Wexford
Phil Jordan
Professor of Catchment Science, School of Geography and Environmental Sciences, Ulster University, Coleraine, Co Derry
Per-Erik Mellander
Research Officer, Teagasc, Crops, Environment and Land-Use Research Programme, Johnstown Castle, Co Wexford
Ger Shortle
Programme Manager, Teagasc, Agricultural Catchments Programme, Johnstown Castle, Co Wexford

Correspondence:
ger.shortle@teagasc.ie

A new surface-runoff index has been developed by the Teagasc Agricultural Catchments Programme to improve the targeting of existing measures designed to reduce diffuse pollution.

In agricultural catchments, heavy rainfall can generate surface runoff, which transports agronomically important soil nutrients such as phosphorus and nitrogen to rivers and lakes. Excessive losses are a major environmental concern worldwide, as they can cause algal blooms (eutrophication), damage drinking water quality and ecosystems, and reduce soil fertility. The EU Nitrates Directive aims to protect vulnerable waterbodies by reducing nitrogen and phosphorus losses from agricultural land through implementation of the Good Agricultural Practices measures. Included are watercourse set-back distances and buffer zones. However, targeting these mitigation measures at locations, where surface runoff is likely to occur, could be a more cost-effective way of meeting water quality objectives, and also sustain intensive agriculture.

This targeting requires accurate models that predict hydrologically sensitive areas (HSAs) at highest risk of generating surface runoff and transporting nutrients, based on factors such as topography and soil properties. This is particularly important in Irish agricultural catchments, because recent Teagasc research suggests that hydrology is a more dominant factor of soil nutrient losses than nutrient concentrations or mobilisation potential. However, models should also account for existing barriers to surface runoff pathways in the landscape, such as hedgerows and small depressions (Figure 1), which are prevalent on farmland in Ireland and much of north-west Europe. This would avoid unnecessary implementation of diffuse pollution mitigation measures at these hydrologically disconnected locations.

Figure 1. Surface runoff and soil nutrient transport being impeded behind a hedgerow (left) and within a depression (right).

The surface runoff index

An HSA Index was developed to model surface runoff and account for hydrological connectivity of pathways to the stream. It is based on a soil-topographic index which predicts risk of surface-runoff generation using soil hydrological properties (soil depth and saturated hydraulic conductivity) and topographic data (upslope drainage area and slope) derived from remotely-sensed high resolution LiDAR Digital Elevation Models (DEMs). The approach then accounts for hydrological connectivity by applying a flow sink algorithm to the DEMs to identify the features in the landscape that could impede runoff and nutrient transport (e.g., depressions and hedgerows).

The size of runoff-generating areas

The HSA Index was applied to four intensively monitored agricultural catchments within the Teagasc Agricultural Catchments Programme – two arable catchments in Co Louth and Co Wexford and two grassland catchments in Co Cork and Co Wexford. The size of HSAs (runoff-generating areas) within the catchments were estimated using rainfall-runoff measurements at catchment outlet gauging stations from 2009-2014. HSAs represented 2.9-8.5% of catchment areas during large rainfall events, and 6.2-22.8% of catchment areas during extreme storms. The most hydrologically sensitive catchments (at greatest risk of nutrient transport and delivery) were the Co Louth arable catchment and Co Wexford grassland catchment, which were dominated by imperfectly and poorly-drained soils. In contrast, the other catchments had low surface runoff propensity due to well-drained soils.

The importance of hedgerows

Hedgerows and depressions were common throughout each catchment, and function as existing mitigation measures that buffer surface runoff. Depending on the catchment, between 800-3,101 of these features were identified as flow sinks that impede surface flow, with total surface runoff volume capacities of 8,298-59,584 m3 (the equivalent of three to 24 Olympic-size swimming pools). Thus, between 16.8-33.4% of catchment areas were predicted to be hydrologically disconnected from the stream, at least in terms of surface runoff pathways (Figure 2). Therefore, implementing mitigation measures in these areas would be unnecessary. Furthermore, the removal of hedgerows and depressions in the landscape could significantly increase agricultural runoff and associated risks to water quality. Therefore, they should be preserved and enhanced.

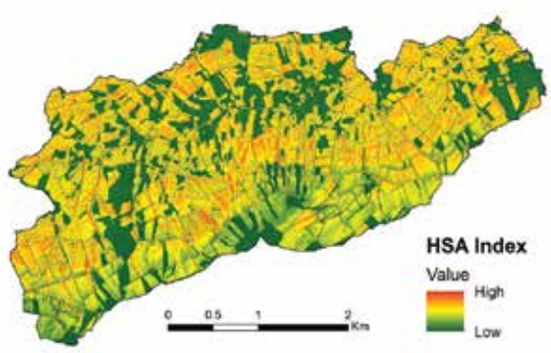


Figure 2. HSA Index map for a grassland catchment. Areas at highest risk of generating (hydrologically connected) surface runoff are in red, and areas where runoff would be impeded are in dark green.

Targeting mitigation measures

HSAs were mapped (Figure 3) by selecting the catchment areas with the highest HSA Index values (where hydrologically connected runoff is predicted) up to the HSA size estimated from the rainfall-runoff data. These maps identified vulnerable 'breakthrough' points and 'delivery' points along surface runoff pathways where diffuse nutrients are being transported between fields and delivered to the watercourse, respectively. These represent the most cost-effective locations for targeting measures (such as riparian buffer strips), particularly if measures are prioritised at the largest HSAs.

To test this, HSA delivery points were proposed as locations for targeting riparian buffer strips within Ireland's Green Low-carbon Agri-environment Scheme (GLAS). A scenario analysis, using different margin widths and LiDAR DEM costs, showed that the targeted approach reduced potential costs, compared to blanket implementation (along all watercourses within the catchment), on average by 66% and 91% over one and five years respectively. The amount of agricultural land potentially taken out of production would also be significantly lower using this targeted approach compared with a blanket approach of complete riverside buffering.

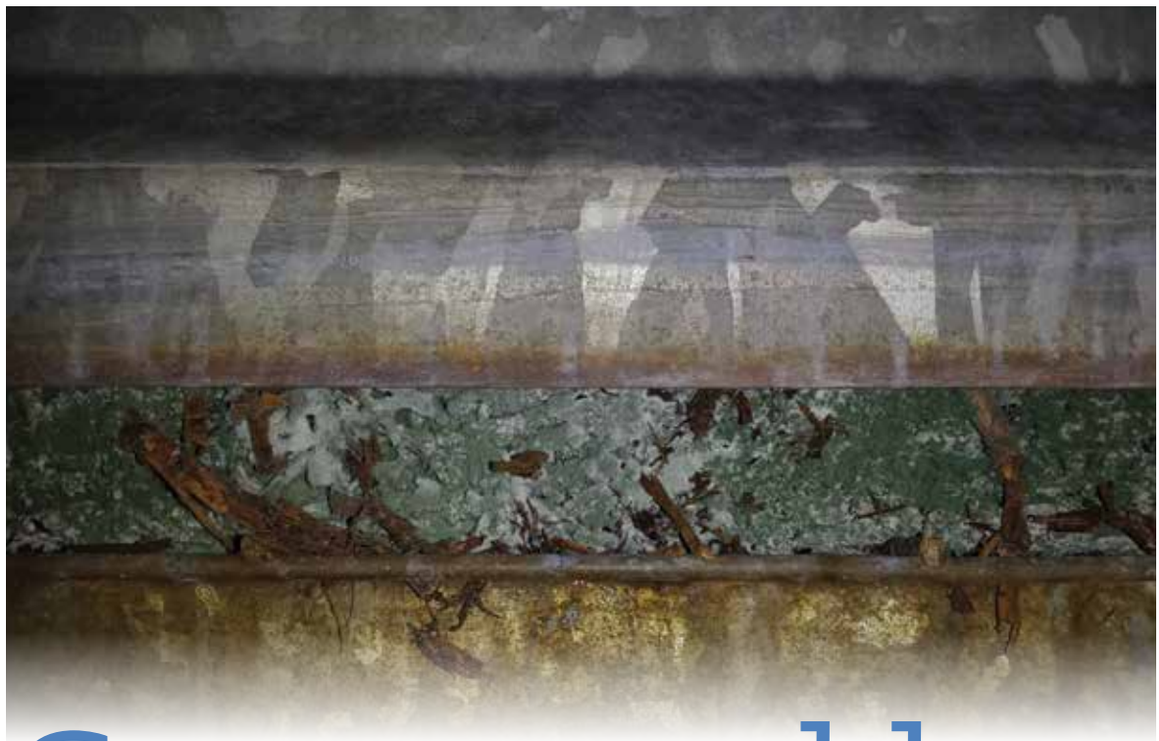
Figure 3. HSA map showing runoff pathways generated during small (red), medium (orange) and large (yellow) rainfall events. Also indicated are breakthrough points at field boundaries (green dots) and a delivery point (blue dot) at the stream (grey line) where mitigation measures should be targeted.

Acknowledgements

This project was funded by the Department of Agriculture, Food and the Marine and the Teagasc Walsh Fellowship scheme (DAFM 6300). We thank catchment farmers for cooperation and access to their land, and staff at the Soil, Environment and Land-Use Department in Teagasc, Johnstown Castle, Wexford. We also acknowledge co-authors Oliver Shine, Rachel Creamer, Noeleen McDonald, Daire Ó hUallacháin, Paul Dunlop and Paul Murphy.

References

Thomas, I.A., Jordan, P., Mellander, P.E., Fenton, O., Shine, O., Ó hUallacháin, D., Creamer, R., McDonald, N.T., Dunlop, P., Murphy, P.N.C., 2016. Improving the identification of hydrologically sensitive areas using LiDAR DEMs for the delineation and mitigation of critical source areas of diffuse pollution. *Science of the Total Environment*. 556, 276-290.



Green mould in mushroom compost

Mairéad Kilpatrick,
Senior Research Officer, Agri-Food and Biosciences Institute, Sustainable Agri-Food Sciences Division, Loughgall, Co Armagh, BT61 8JB, Northern Ireland
Helen Grogan,
Senior Research Officer, Horticulture Development Department, Teagasc Food Research Centre, Ashtown, Dublin 15

Correspondence:
helen.grogan@teagasc.ie

A joint research project carried out by AFBI in collaboration with Teagasc tackles the problem of green mould in mushroom compost.

Trichoderma aggressivum, or mushroom compost green mould, was first reported in Ireland in the late 1980s during a period of rapid expansion of Phase 2 compost production and the bag cultivation system. In the mid-1990s, a separate outbreak occurred in Canada, caused by a similar but different strain of *T. aggressivum*, again associated with rapid industry development. Bulk Phase 3 (fully spawn-run) compost, at the time, appeared to be unaffected and it wasn't until the late 1990s and early 2000s that *T. aggressivum* was reported among growers using Bulk Phase 3 compost. Initially, there was confusion about where the green mould was coming from. The compost 'looked' healthy and well colonised with *Agaricus* mycelium, but growers getting different batches from the same tunnel were reporting different levels of infection ranging from none to total crop wipe-outs. Importantly, research from the EU-funded project 'MushTV' has now identified how this compost mould behaves within the Bulk Phase 3 system.

Inoculation studies in bulk tunnels

Three sets of inoculation studies were carried out whereby *T. aggressivum* was artificially introduced into the back of small-scale Bulk Phase 3 tunnels (2m x 1m x 2.5m), at the Agri-Food and Biosciences Institute (AFBI) Experimental Mushroom Facilities, Loughgall, Northern Ireland.

- The first trial tracked the growth of the *Trichoderma* from the point source of infection through four vertical and three horizontal planes (12 distinct sub-sections).
- The second trial quantified *Trichoderma* growth when compost was removed from the tunnel in four equal 'slices' from the front to the back of the tunnel (each section individually well mixed).
- The third trial recorded productivity following standard commercial 'bulk handling' practice for emptying Phase 3 compost; i.e., removing the compost vertically from front-to-back of the tunnel onto a compost conveyor that, in turn, layers it horizontally into a transport container, subsequently emptying it vertically again from the transport container onto the shelves in the growing unit (Figure 1).

'Bulk handling' involves several levels of mixing, which results in the contents of the tunnel being thoroughly combined and homogenised, thereby minimising potential variations in compost performance.

Figure 1. Bulk handling of Phase 3 compost at tunnel emptying.

Trichoderma growth in tunnels

The results from the first trial indicated that the *Trichoderma* was not clearly visible in the compost at emptying, supporting reports from the industry that the compost 'looked healthy' and free of green mould. However, when the compost was cropped, it was evident that *Trichoderma* growth in the back sub-sections, close to the point of infection, negatively impacted yield with 24%, 42% and 100% yield loss through top, middle and bottom sub-sections, respectively, while compost from further away yielded normally (Figure 2). The overall average tunnel yield loss was approximately 12%. Similarly, when the tunnel was emptied in four equal 'slices' and the compost cropped, yields from the front three sections were normal; while yield from the back (now fully mixed section), where the *Trichoderma* infection had been added, was effectively reduced to zero (resulting in a tunnel average of 25% crop loss). In contrast, when the compost was emptied, following the commercial practice of bulk handling, it again 'looked healthy'; however, the productivity for the entire tunnel was dramatically reduced (approximately 85% to 90% crop loss). Thus, the bulk-handling operations are a key factor in exacerbating the impact of a localised infection inside the tunnel.

Figure 2. Effect of green mould on mushroom production.

Contaminated equipment spreads infection

At the specific behest of industry, two final trials, as outlined below, were conducted to ascertain the impact of using contaminated emptying equipment on tunnels of compost with no green mould infection present. In these trials, three tunnels of compost were consecutively filled: the first inoculated at the front of the tunnel with *T. aggressivum* and the remaining two tunnels conventionally filled with no *Trichoderma* added.

The contaminated tunnel (T1) was emptied vertical-section-by-vertical-section (four in total) using the compost conveyor and trailer as before; and when, cropped, each 'slice' of compost yielded poorly due to *T. aggressivum* (70% to 90% yield loss). Thus, the contaminated equipment that handled the infected compost at the front of the tunnel had contaminated the remainder of the tunnel, leading to poor yields from each section of compost (Figure 3). The contaminated emptying equipment was then used to empty a second tunnel (T2), again section-by-section (four in total) and, in this instance, there was a lesser but significant reduction in yield of approximately 30% of the control. At this point, the emptying hall was cleaned and disinfected to remove any *T. aggressivum* contamination present, but the emptying and transport equipment were first removed from the building and left uncleaned. The following day, the third tunnel (T3) was opened and the first section of compost was manually emptied (with clean equipment) and this cropped well (approximately 0% yield loss) with no green mould detected. The remaining three sections of compost were then removed using the uncleaned contaminated equipment from the day before and, once again, the contaminated equipment transferred *T. aggressivum* to the compost, with yields reduced considerably to between 30% to 85% of the control; the three final sections averaging over 50% yield loss.

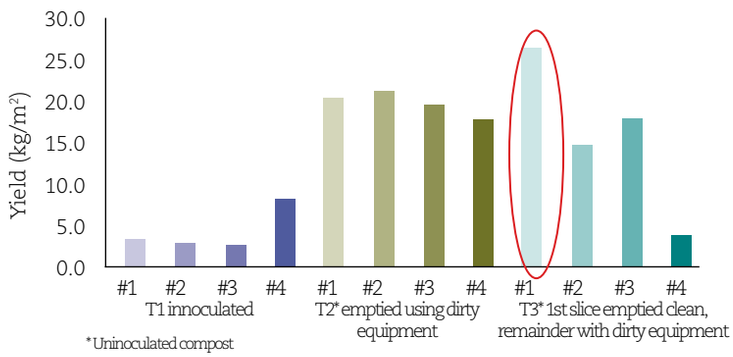


Figure 3. Yield per 'slice' of Phase 3 compost from three tunnels.

Conclusion

This series of trials has clearly demonstrated that *T. aggressivum* growth in a bulk incubation tunnel remains quite close to the point of infection, just to within about a 0.5-1m radius. However, once that infected compost is mixed, bulk handled and transported, it very effectively contaminates healthy spawn-run compost, causing significant crop reduction during the cropping period. Uncleaned contaminated equipment was also shown to be very effective at spreading the disease into otherwise healthy compost, negatively impacting yields. Best practice guidelines have been transferred to industry in a technical factsheet.

Acknowledgement

Caoimhe Fleming-Archibald (Teagasc) and David Burns, Stephen Sturgeon and Paula McPoland (AFBI) also contributed to this work. This project was funded by the European Union Seventh Framework Programme (FP7-SME-2011) grant agreement number 286836 (MushTV). The positions expressed reflect the authors' views.

Thermal stability of whey protein concentrates

Aoife Buggy,
Research PhD Student,
André Brodkorb,
Research Officer,
Mark Fenelon,
Head of Food Programme,
Food Chemistry and Technology Department,
Teagasc Food Research Centre,
Moorepark, Fermoy
Co Cork

Correspondence:
aoife.buggy@teagasc.ie

With market trends showing signs of increased demand for protein-rich foods, Teagasc has investigated the potential of whey protein concentrates as a food ingredient.

The abolition of milk quotas in March 2015 has resulted in significantly more milk being produced in Ireland and across Europe. Milk is an important source of nutrition for mammals during infant development and is a complete food source as it contains all major macronutrients, i.e., protein, fat and carbohydrate. The two main fractions of protein found in bovine milk are casein and whey proteins (80% and 20% of the total protein respectively). In addition to potential health benefits, there is particular interest within the food sector in the functional properties of whey proteins, e.g., foaming, emulsification and gelation properties, which can be utilised in the manufacture of a variety of foods (El-Salam *et al.* 2009).

Current market trends suggest that the demand for food formulations containing concentrated protein for nutritional proposes will continue to grow. Increased focus on healthy lifestyle across all age categories is driving innovation in a range of areas e.g., nutritional beverages (infant formula, medical and therapeutic), nutrition bars and sports and weight-management supplements. Scientific discovery, encouraged by food and medical research, has identified important benefits of individual whey proteins through their excellent amino acid profile and functionality e.g., α-lactalbumin and lactoferrin for special medical purposes and/or muscle development.

Heat stability

The thermal stability of whey proteins is an important factor to consider when producing a food product, as the application of heat is commonly applied to reduce bacterial load. Heating alters the structure of whey proteins, as their globular structure begins to unfold and denature at temperatures greater than 64°C. The unfolding of protein can expose reactive sites, which are buried within the native globular structure of the protein. The binding of two of these exposed reactive sites creates linkages that can cause aggregation of protein and, in severe cases, precipitation or even protein gelation (Zuniga *et al.* 2010). This can be problematic during the manufacture of formulations containing bovine whey proteins due to changes in protein functionality during thermal processing.

Engineering heat stability

Research at Teagasc has focused on the characterisation of aggregates created through the heat treatment of whey protein isolates (WPI) with different protein concentrations, i.e., (1%, 4%, 8% and 12% protein) at pH 6.7 (pH of milk; trials carried out in quadruplicate). Heat treatment conditions were kept constant throughout all trials, with a pre-heating temperature of 65°C and a final-heating temperature of 85°C, with a holding time of 30 seconds. As this temperature is greater than 64°C, denaturation and subsequent aggregation of the whey protein was induced, forming whey protein aggregates that were characteristically different. By measuring different parameters, i.e., protein aggregate size, turbidity, soluble aggregate formation and secondary structure of aggregates formed during heating, it was possible to determine which concentration of protein produces

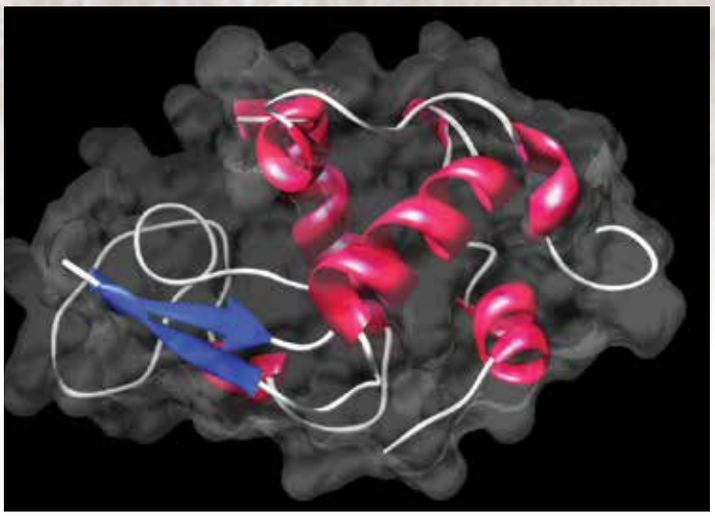


Figure 1. 3D structure of a globular whey protein in its native state as found in nature.

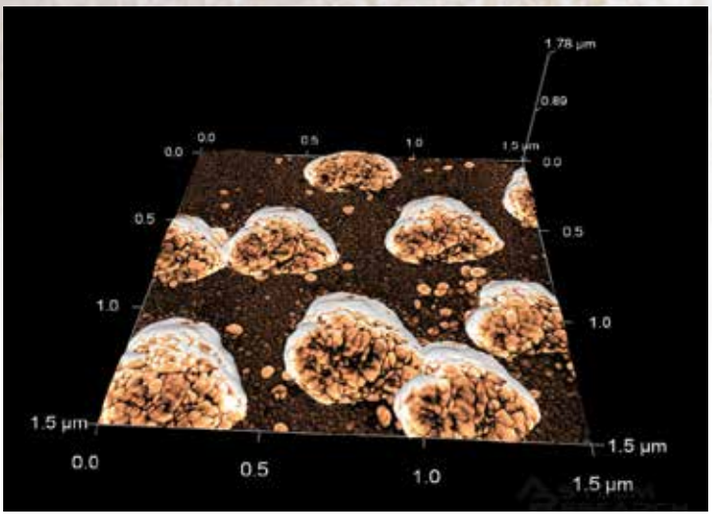


Figure 2. Atomic force microscopy image of whey protein aggregates formed post-heat treatment by the aggregation of denatured whey protein.

the most thermally stable WPI aggregates. The heat treatment of 1% and 12% WPI resulted in a decrease in the Z-average particle size (measured using dynamic light scattering) from 99.7±2.5nm to 58.7±1.9nm, respectively. The turbidity of samples heat treated at the same pH is similar in trend; a decrease in the cloudiness of the whey protein solution was observed for samples heat treated at 12% WPI when compared to the more cloudy samples produced upon heat treatment of 1% WPI. However, results for soluble aggregate formation demonstrated the opposite trend. The term 'soluble aggregate' in this instance is used to describe protein that has been denatured and has undergone aggregation, but has remained soluble within the protein system. The soluble aggregates formed differ from the larger whey protein aggregates measured by dynamic light scattering, as they are significantly smaller in size and cannot be seen with the naked eye. Samples that were heat treated at 1% WPI contained soluble aggregates with smaller molecular weight sizes when compared to samples that were heat treated at 12% WPI. Through the use of Fourier transform infrared spectroscopy (FTIR), differences in the secondary structure of the heat-treated samples were observed. Noticeable differences in secondary structure between 1% and 12% WPI concentrations were detected when samples were compared after heating. These changes in structure are the driving force behind protein aggregation and are why differences in particle size and turbidity are evident at differing protein concentrations.

The findings demonstrate variation in particle characteristics of different concentrations of WPI heat treated at pH 6.7. Further experiments were carried out where the samples of 1% WPI were concentrated to 12% protein (rotary evaporation), thereby producing two 12% samples with differing Z-average particle size. Heat stability was assessed by using a widely recognised method where the samples are placed in an oil bath at 100°C and observed until the point of visible aggregation. The results indicate that differences in heat stability can be achieved through the pre-heat treatment of WPI at different protein concentrations. The findings can be utilised for improving processing characteristics of whey protein ingredients in multiple food applications.

Acknowledgements

This work was supported by the Department of Agriculture, Food and the Marine and the Food Institutional Research Measure (project 11/F/037). Aoife Buggy was funded under the Teagasc Walsh Fellowship Programme. The authors would also like to acknowledge the National Imaging Centre at Teagasc Moorepark.

References

El-Salam, M. H. A., *et al.* (2009). 'Factors Affecting the Functional Properties of Whey Protein Products: A Review'. *Food Reviews International* 25(3): 251-270.

Zuniga, R., *et al.* (2010). 'Kinetics of Formation and Physicochemical Characterization of Thermally-Induced beta-Lactoglobulin Aggregates'. *Journal of Food Science* 75(5): 261-268.

Rapeseed for heart health

Maria Hayes,
Research Officer, Teagasc Food Research Centre, Ashtown, Dublin 15
Leah Quinn,
Teagasc Walsh Fellow PhD candidate, Teagasc Food Research Centre, Ashtown, Dublin 15
Steve Meaney,
School of Biological Sciences, College of Sciences and Health, Dublin Institute of Technology
Steven Gray
Department of Clinical Medicine, St James's Hospital, Dublin

Correspondence:
maria.hayes@teagasc.ie

Researchers are looking at the use of phenolic-rich rapeseed by-products for development of functional, heart-healthy foods.

Rapeseed *(Brassica napus L.)* is one of the world's major oilseeds with rapeseed oil produced from pressing the seeds. Winter oilseed rape varieties grown commercially in Ireland are classified as *Brassica napus* (Swede Rape) and all have low levels of both erucic acid and glucosinolates. These varieties are known as 'double zero varieties' and their seed is suitable for processing for both food and feed use. The crop is usually grown in rotation with cereals, with usually two or more years between successive crops in the same field (Department of Agriculture, Fisheries and Food, 2009). Rapeseed oil production results in the by-product rapeseed meal. This by-product is rich in polyphenols, including sinapinic acid (SA) and protocatechuic acid (PCA), and these phenolics are thought to have several beneficial health effects including anti-inflammatory and anti-diabetic applications. SA is a small, natural hydroxycinnamic acid often used in mass spectrometry as a standard. PCA is also found as an antioxidant in green tea and has been studied previously for its effect on cancer cells. Leah Quinn, a PhD candidate at Teagasc Ashtown, is currently researching the beneficial effects of SA and PCA on heart health in conjunction with researchers at Dublin Institute of Technology, Trinity College Dublin and St James's Hospital, Dublin.

Extraction and characterisation of SA and PCA

High blood pressure, or hypertension, is the single largest risk factor attributed to deaths worldwide (World Health Organization [WHO], 2009). Hypertension is responsible for 12.8% of deaths globally, affecting all countries, and all income groups (WHO, 2009). Furthermore, high systolic blood pressure is globally attributable to 51% of stroke, 45%

of ischaemic heart disease and between 37% (South-East Asia region) and 54% (European countries) of cardiovascular deaths (WHO, 2009). Hypertension is, therefore, a considerable problem in our society, not only placing a great burden on our health, but also having substantial impacts on the economy.

An angiotensin-converting-enzyme inhibitor (ACE inhibitor) is a component used primarily for the treatment of hypertension (elevated blood pressure) and congestive heart failure. ACE-I is a zinc-dependent peptidase that cleaves angiotensin I to angiotensin II (ANG II), a vasoconstrictor, involved in regulating blood pressure. Aside from playing a key role in hypertension, ANG II induces cardiovascular damage through its effects on smooth muscle migration and the formation of extracellular matrix, resulting in vascular remodeling and endothelial dysfunction. The use of ACE-I inhibitors suppresses ANG II, thereby reducing high blood pressure, along with reducing the risk of myocardial infarction and mortality in high-risk patients, such as those with diabetes or vascular disease.

The aim of this work was to generate phenolic fractions containing SA and PCA from rapeseed meal, and to test these extracts for their ability to inhibit the enzyme angiotensin-converting enzyme I (ACE-I; EC 3.4.15.1). This enzyme is key to the development of high blood pressure in humans and, if it can be inhibited, can result in reduced blood pressure in persons with high blood pressure.

Scientific approach used

A phenolic acid-rich extract was generated that included SA and PCA using the method of Naczk *et al.* (1992), which is outlined briefly in Figure 1.

Total phenolics (fraction 1): Defatted meal was extracted and repeated five times with a methanol: acetone: water mix (7:7:6 v:v:v), before being vortexed for 15 sec and centrifuged at 5,000rpm for 15 min. The supernatants were combined and reduced using rotary evaproation at 30°C. This fraction contains total phenolics (fraction 1).

↓

Free phenolic acids (fraction 2): F1 was extracted six times with diethyl ether:ethyl acetate (1:1). The clear layers were pooled together, evaporated to dryness and labelled as free phenolic acids (fraction 2).

↓

Soluble esters (fraction 3): Fraction 1 was hydrolysed with 4M NaOH for 4 hours at room temperature. The hydrolysed solution was then acidified to pH2 using 6M HCl. The acidified solution was then etracted six times with diethyl ether:ethyl acetate (1:1) and the clear layers pooled. The combined supernatants were then evaporated to dryness and labelled as soluble esters (fraction 3).

Figure 1. Method used for extraction of SA and PCA from rapeseed meal.

Measuring ACE-I inhibition

The ACE-I inhibition assay was used to determine the ability of the phenolic fractions isolated from rapeseed meal to inhibit ACE-I. The compound 3-hydroxybutyryl-gly-Gly-Gly (3HB-GGG) was used as an ACE-I substrate and the amount of cleaved 3-Hydroybutyric acid (3HB) from 3HB-GGG was detected using spectrophotometry.

Results

Figures 2 and 3 show the percentage ACE-I inhibition by each of the rapeseed meal extracts generated and the percentage ACE-I inhibited by the control, Captopril, which is a commercially available antihypertensive drug. IC_{50} values are shown in Figure 3.

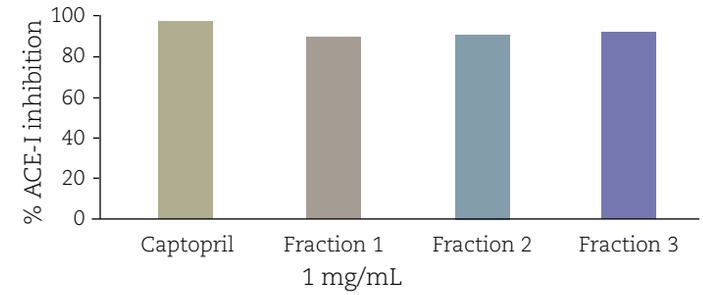


Figure 2. ACE-I inhibitory activity of rapeseed meal phenolic extracts and Captopril, expressed as % ACE-I inhibition. Data expressed as mean ± SEM (*n*=3).

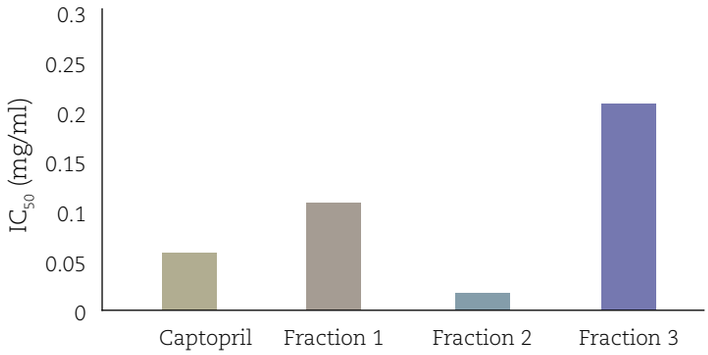


Figure 3. IC_{50} values of ACE-I inhibition for rapeseed meal phenolic extracts and Captopril, expressed as mg/ml. (n=1).

Industry relevance

Extraction of phenolic compounds, including SA and PCA from rapeseed meal, allows the valorisation of a low-economic-value by-product of the rapeseed de-oiling process through their potential utilisation as functional food ingredients to improve human health.

Acknowledgements

Leah Quinn is in receipt of a Teagasc Walsh Fellowship (Grant reference number 2015015). Rapeseed meal was kindly supplied by Donegal Rapeseed Oil, Raphoe, Co Donegal. The authors wish to acknowledge the contribution of Stephen Finn, Department of Histopathology, Central Pathology Department, St James's Hospital, Trinity College, Dublin, to this project.

References

Department of Agriculture, Fisheries and Food. (2009) 'Winter Oilseed Rape Varieties, Irish recommended list for 2009 sowing', 6 pages.

WHO. (2009) 'Global health risks: mortality and burden of disease attributable to selected major risks', 63 pages

Naczk, *et al.* (1992) 'Facile Spectrophotometric Quantification Method of Sinapinic Acid in Hexane-extracted and Methanol-Ammonia-Water-Treated Mustard and Rapeseed Meals'. *Journal of Agricultural and Food Chemistry*, 40: 444-448.

Investment in agricultural R&D

There is good data available on overall public and private-sector research and development (R&D) expenditure for Ireland. However, specific data on agricultural R&D expenditure is not as extensively available and there is a particular lack of readily available data on private-sector expenditure on agricultural R&D.

Kevin Heanue, Evaluation Officer, Business Planning Performance and Evaluation Department, Teagasc, Athenry, Co Galway
Ultan Shanahan, Agrifood Business and Spatial Analysis Department, Rural Economy and Development Programme, Teagasc, Ashtown, Dublin (Not pictured)

Correspondence: kevin.heanue@teagasc.ie

In terms of trends, Government expenditure on agricultural R&D decreased by 10.3% between 2002 and 2012 and the share of agricultural expenditure on R&D to total expenditure fell from an average of 5.6% at the beginning of the period to 3% at the end. These were some of the key findings from a recent national expert report for the EU FP7-funded IMPRESA project compiled by Kevin Heanue and Ultan Shanahan from Teagasc's Rural Economy and Development Programme.

The IMPRESA project, implemented between November 2013 and December 2016, comprises nine participants from research institutes, universities, international organisations and a small-to-medium enterprise (SME), from six European countries (www.impresa-project.eu). The project seeks to evaluate the impact of EU research on agriculture, collecting data on recent trends in investment in agricultural research, and developing a framework that combines case studies, econometric analysis and modelling to assess its impact. The project's first task was to prepare country-level analysis of agricultural research expenditures and an assessment of the availabilities of data regarding public and private investments in agricultural research. The Irish expert report focused on the period from 2002 to 2012/2013.

Availability of data

To explore the availability of Irish data on agricultural R&D, interviews were conducted with personnel in the Central Statistics Office (CSO) and the Strategic Policy Division (SPD) of the Department of Jobs, Enterprise and Innovation (DJEI). The CSO and SPD are responsible for generating and collating Irish data on R&D expenditures. Data on the main categories of R&D expenditure (Gross Domestic Expenditure on R&D [GERD], Business Expenditure on R&D [BERD], Higher Education R&D [HERD] and Government Budget Appropriations or outlays on R&D [GBAORD]) are publicly available since at least 1980. GERD is the main indicator of investment in research. It includes BERD, HERD and Government intramural expenditures on research and development (GOVERD), as well as private, nonprofit organisations' expenditure. Sector-specific spend on R&D is provided by two nomenclatures in the data sets: the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS) and the Fields of Science (FOS). Although GERD is a reliable indicator of investment in research, its disaggregation by sector is problematic as details are not provided for all sectors. In addition, there is limited data on private-sector expenditures on individual categories of R&D.

GBAORD refers to budget provisions, not actual expenses. Data include both current and capital expenditures and cover not only Government-financed research and development performed in Government establishments, but also Government-financed R&D in the private sector. The disaggregation by sector is only available for NABS.

Detailed information on the temporal and categorical availability of R&D expenditure data for Ireland is presented in Table 1, which show clear gaps in terms of agricultural-specific data and private-sector data.

Table 1

Indicator	Time series available
GERD	
All areas	1981-2012 (2013 for Government sector)
By FOS (agricultural sciences)	
All sectors Business enterprise sector Government sector Higher education sector Private non-profit sector	- Not available 2002-2013 2001-2012 Not available
By NABS 1992	
All areas	
Chapter 6 - Agricultural production and technology All sectors Business enterprise sector Government sector Higher education sector Private nonprofit sector	 Not available Not available 2002-2006 Not available Not available
By NABS 2007	
All areas	Not available
Chapter 8 - Agriculture	
Government Sector	2003-2013
BERD	
By Nomenclature Statistique des activités économiques dans la Communauté européenne (NACE) (Statistical classification of economic activities in the European community) rev. 1.1	
All areas	2000-2010
A B - Agriculture, forestry and fishing	2001-2005
DA15 - Manufacture of food products and beverages	2001-2005
By NACE rev. 2	
All areas	2005-2012
A - Agriculture, forestry and fishing	2011
C10 C11 - Manufacture of food products and beverages	Not available
GBAORD	
By NABS 1992	
All areas	2000-2003
NBS06 - Agricultural production and technology	2000-2003
NBS1107 - Agricultural sciences	2000-2003
By NABS 2007	
All areas	2000-2013
NABS08 - Agriculture	2004-2013

Trends in R&D investment

Given the data availability, Figure 1 outlines trends in GERD and agricultural R&D expenditure (Government and higher education) over the period 2002-2012.

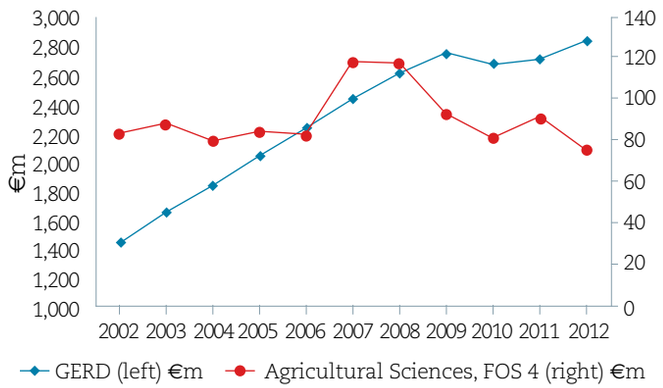


Figure 1. GERD (in current prices) and agricultural R&D expenditure, 2002-2012.

There are several notable features in Figure 1. First, GERD displays a generally smooth growth trajectory. Second, expenditure on agricultural R&D has been more volatile. Overall GERD shows an upward trend over the period, increasing by 96.8%. Within this trend, between 2009 and 2010, there was a decline of 2.4% and then a recovery of 0.10% in total GERD in 2011, followed by an increase of 4.8% in 2012. By contrast, agricultural expenditure on R&D (which in this figure only includes Government and higher education sector expenditure) displays an inverted u-shape. It was relatively flat in the period 2002 to 2006, with a sharp increase of 43.9% in 2007, followed by a continued reduction of 31.4 % from 2008 to 2010, with an increase followed by a decline in 2011 to 2012. In overall terms, agricultural expenditure on R&D declined by 10.3% over the period. In relative terms, the share of agricultural expenditure to GERD fell from an average of 5.6% at the beginning of the period to 3% at the end.

Acknowledgements

The authors would like to thank personnel in the Central Statistics Office and Department of Jobs, Enterprise and Innovation for explanation of the data sets. Thanks are also due to the IMPRESA project which received funding from the EU's Seventh Framework Programme under grant agreement No. 609448.

References and associated publications

Heanue, K., and Shanahan, U. (2015) *Study on Investment in Agricultural Research: Review for Ireland,* IMPRESA country report: Ireland, http://www.impresa-project.eu/fileadmin/user_upload/IMPRESA/Filesharing/IMPRESA_country_report_Ireland.pdf

The Science Budget 2014-2015 https://www.djei.ie/en/Publications/Publication-files/The-Science-Budget-2014-2015.pdf

Survey of Research and Development in the Higher Education Sector 2012/2013 https://www.djei.ie/en/Publications/Survey-of-Research-and-Development-in-the-Higher-Education-Sector-2012-2013.html

Business Expenditure on Research and Development 2013-2014 (BERD) http://www.cso.ie/en/releasesandpublications/er/berd/businessexpenditureonresearchdevelopment2013-2014/

Returns on afforestation of agricultural land

Mary Ryan,
Environmental Economist, Agricultural Economics and Farm Surveys Department, Teagasc, Athenry
Cathal O'Donoghue,
Dean of Arts, Social Sciences and Celtic Studies, NUI Galway
Anne Kinsella,
Research Officer, Agricultural Economics and Farm Surveys Department, Teagasc, Athenry

Correspondence:
mary.ryan@teagasc.ie

This article examines the factors affecting the returns from the afforestation of agricultural land.

Forestry is a long-term crop with rotations of over 30 years for fast-growing conifers, and up to 100 years for slower-growing broadleaf species. Planting a fast-growing conifer will yield an annual tax-free forest premium of €510/ha for the first 15 years of the forest rotation. After this period, the economic return from forestry arises mainly at final harvesting, with intermediate income if forests are thinned.

Farm income relative to forest premium payments

Comparing farm incomes in one year relative to forest premium payments can give an indication of how the net farm income (including subsidy) for different farm systems, relates to the forest premium payment (subsidy only). The principal measure used to represent the return from farming in the Teagasc National Farm Survey (NFS) is Family Farm Income (FFI). The latest Teagasc NFS (2015) reports that average FFI/ha ranges from €1,112 for the dairy system to €323 for the sheep system; and from €329 to over €400/ha for cattle rearing and other cattle systems, respectively.

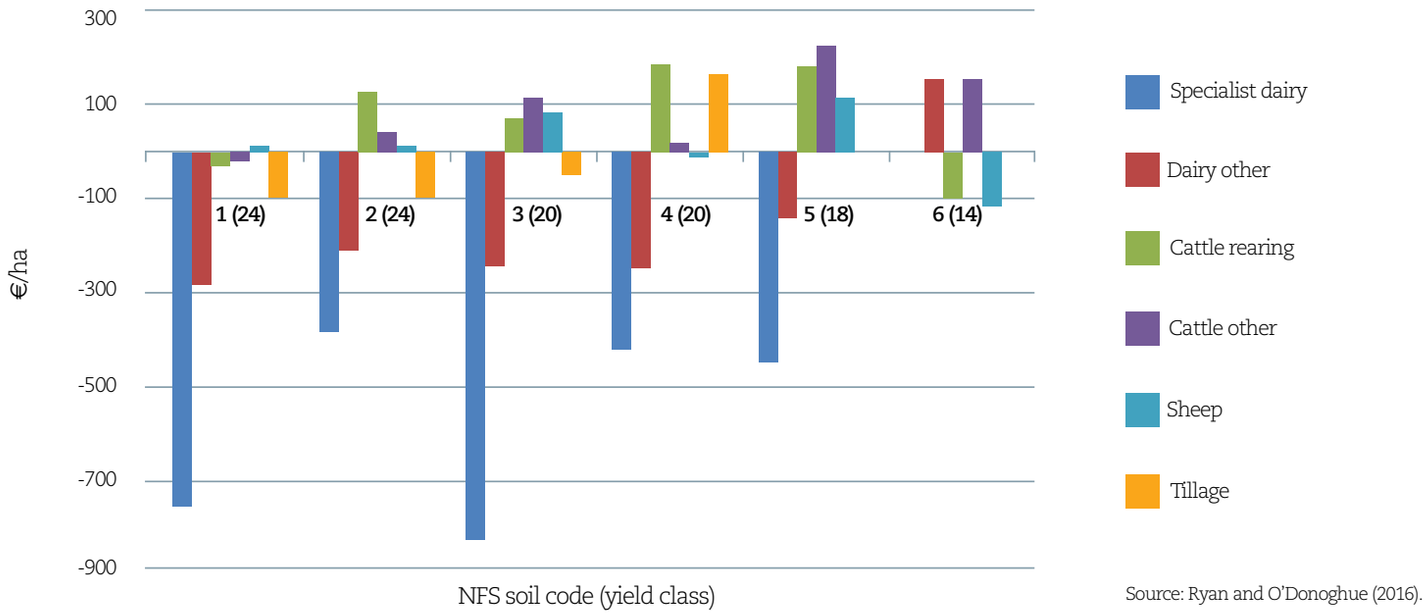
However, making a decision on the basis of the figures applying for one year only, is taking a short-term view. For a long-term land-use change, such as forestry, landowners should take into account the full range of factors that affect the returns from forestry, i.e., the costs and revenues from managing and harvesting timber over the lifetime of a forest. These can be projected forward using forest growth (yield) models and average historic timber prices. The return from forestry is largely determined by soil type, which, in turn, determines timber yield.

Table 1 shows the relationship between agricultural soil classes, where soil class (SC) 1 is the best soil and SC 6 is the poorest. Higher forest yield classes produce more timber and higher financial returns.

Table 1. Sitka spruce (SS) yield class estimates for NFS agricultural soil classes. Source: Upton *et al.* (2013).

Soil Class (SC)	Agricultural use	Soil type	SS yield class
1	Wide	No limitations	24
2	Moderately wide	Minor limitations	24
3	Somewhat limited	Higher elevations, heavier, poorer structure	20
4	Limited	Poor drainage	20
5	Very limited	Agricultural potential greatly restricted	18
6	Extremely limited	Mountainous, steep slopes, shallow soil	14

Landowners, who plant agricultural land, incur an opportunity cost in relation to the loss of agricultural income on the planted land over the lifetime of the forest. The opportunity cost of planting for individual farmers varies greatly depending on the farm system, as well as the soil type.



Source: Ryan and O'Donoghue (2016).

Figure 1. Annualised, long-term net gain/loss from land-use change from agriculture to forestry (annual equivalised net farm afforestation income per hectare – CPI adjusted) by farm system and soil class (SC), based on 2015 agricultural incomes and forest premiums, over the forest rotation.

The agricultural opportunity cost is made up of income form the market, as well as subsidy income and changes over time as costs, prices and subsidies change. Following a period of stability in recent years, average FFI increased by 5% in 2015. However, income still lags behind the record levels recorded in 2011.

One of the advantages of forestry as a crop is that long-term timber prices have kept pace with inflation. In addition, it is possible to capitalise on high timber prices by harvesting a year or two earlier/later. Fluctuations in farm incomes over time (e.g., from the adverse weather in 2009 to high market prices in 2011), affect the opportunity cost of planting. Policy changes also affect the opportunity cost. Thus, farmers who are considering forestry should look at the longer-term financial and physical components of the agricultural enterprise in conjunction with the long-term returns from the proposed forest enterprise.

Long-term net gain/loss from planting

Analysis undertaken by Teagasc calculates the afforestation income resulting from the planting of a conifer (Sitka spruce GPC3) crop for each of the farm systems. The analysis assumes that planting takes place in 2015 and converts costs and revenues arising throughout the forest rotation into today's money, before generating the equivalent of an annual forest income (annual equivalised value) on a per hectare basis across each year of the forest rotation, using 2015 forest premium and FFI figures. The annual agricultural income that landowners would lose for that soil type is included as a cost in each year of the rotation. Therefore, the annual equivalised income generated is net of the agricultural opportunity cost, i.e., net gain/loss over time from planting.

Farm system and soil type perspectives

From an individual farm perspective, soil productivity and farm system both have a large impact on the long-term net return. As dairy farmers have the highest opportunity cost, they stand to lose significantly more by converting to forestry. This is also the case, to a lesser degree, for dairy other and tillage systems. However, the average annual net return across all but the best and worst soil types is positive for cattle systems and is highest on land of limited use, which is marginal for agricultural use, showing that these farmers stand to gain up to €228 per hectare depending on soil class and system on average, for each year of the forest rotation. The net return from changing from a sheep system to forestry is largely similar.

Conclusions

This analysis presents a long-term perspective that smooths out annual fluctuations and shows that:

- for higher-income farm systems, the opportunity cost is higher so there can be a net loss from planting. The losses are greater on good-quality soils.
- the farmers who stand to benefit the most from planting are those in the cattle and sheep systems, who are likely to plant land that is marginal for agriculture but which is highly productive for forestry. The highest gains are evident on marginal land at yield classes 18 and 20.

Acknowledgments

This study was funded by the Teagasc Core Fund.

Authors' footnote: The agricultural and forest incomes presented above are pre-tax incomes and do not take into account the different treatment of agricultural and forest incomes. Income from forest premiums and sales of timber, up to certain thresholds, is not liable for income tax.

References

Ryan, M. and O'Donoghue, C. (2016) Incorporating Agricultural Opportunity Costs in the return to Farm Afforestation. Rural Economy Working Paper Series. Teagasc, Athenry (Reference code 16wpre01). Available online: www.teagasc.ie

Upton, V., Ryan, M., Farrelly, N. and O'Donoghue, C. (2013). 'The Potential Economic Returns of Converting Agricultural Land to Forestry: An Analysis of System and Soil Effects from 1995 to 2009'. *Irish Forestry* 70 (1&2): 61-74.

Farm succession and inheritance: Investigating policy

Brian Leonard,
PhD candidate, Teagasc and National University of Ireland, Galway (NUIG)
Anne Kinsella,
Research Officer, Teagasc Agricultural Economics and Farm Surveys Department, Athenry, Co Galway
Maura Farrell,
Lecturer, Discipline of Geography, NUIG
Marie Mahon,
Lecturer, Discipline of Geography, NUIG
(not pictured)

Correspondence:
brian.leonard@teagasc.ie

The age of Ireland's farming population is an ongoing concern, with farmers reluctant to transfer farms to a younger generation. New research from Teagasc suggests that without a strong policy incentive this fact is unlikely to change and may result in an agricultural industry that does not reach its full potential.

The process of farm succession and inheritance is highly complex and involves a variety of actors, ranging from family members to professionals, providing advice on legal and financial matters. In most European countries, the family farm model is the predominant form of ownership with farm transfer commonly taking place generationally. Factors affecting the decision to transfer a family farm can be both social and economic, with farmers aiming to ensure family members are provided for when the farm is transferred. Policy effects and economic concerns about various capital taxes and future income can also have a very strong influence on farmer choices.

In many developed countries, there is concern over the ageing farming population and Ireland is no exception. The 2015 Teagasc National Farm Survey showed the average age of farmers as 57. This figure has increased marginally year on year over recent decades with the number of farmers under the age of 40 decreasing over the same period of time. This trend has become a source of major concern for the agricultural sector, given the evidence from a number of studies of a positive correlation between younger farmers and farm efficiency and innovation.

In Ireland, a stifled land market has resulted in very low land mobility and there is a clear pattern of capital accumulation among older farmers who are fearful about their financial future and unwilling to transfer their farm assets (Matthews, 2014). Furthermore, State assistance to agriculture provides direct payments to farmers, making it financially beneficial to hold on to agricultural land rather than transferring it. The result is a sector dominated by older farmers, with access for young farmers an increasingly problematic issue. Adding to this is the issue of farm viability, with one-third of farms in 2015 categorised as vulnerable and a further one third viable (Teagasc National Farm Survey [NFS]). This has a strong effect on farm transfer because low farm income leads to concerns over the farm's capability of providing an income for both the farmer and/or their successor. This can also result in problems of inadequate retirement income for the farmer, leading to land retention as a form of financial security.

Current Irish transfer policy

There are three capital taxes that apply to farm inheritance in Ireland: Capital Gains Tax (CGT), Capital Acquisitions Tax (CAT) and Stamp Duty. CGT applies only to the farmer transferring land out of their name and it is charged at 33% of the value the property gained between date of acquisition and date of sale and/or transfer. CAT is applicable to the successor and is charged at 33% of the value of the property acquired. Stamp Duty is also applicable to the successor, with this being charged at 2% of the value of the property, but can be reduced to 1% based on the relationship of the farmer to the successor. For each of these taxes, certain reliefs apply (Leonard *et al.*, 2017). Other policy incentives to facilitate earlier transfer are young farmer top-ups on Basic Farm Payments (BFP) and other direct payments. Farmers under the age of 40 who have a minimum level 6 agricultural certificate may receive a 25% top-up on their BFP.

Methodology

For this research, hypothetical microsimulation was used to assess the policy environment. This technique allows for the creation of hypothetical farms and models how they interact with current policies. In this case, average Teagasc NFS income figures were used to investigate how various beef and dairy farm decisions interacted with farm inheritance taxes.

One scenario model is a farm on which the farmer transfers all farm assets to their successor on death. Another model is a farmer who destocks the land at pension age to retain farm payments (Less Favoured Area and Basic Farm Payment), and transfers assets on death.

Main findings

The modelling produced outcomes in the outlined scenarios for both the farmer and the successor. The successor fulfilled all the required criteria for reliefs so that in all scenarios the successor was not subject to any capital taxes when farm assets were transferred.

In the case of the farmer, no capital taxes were incurred as the farm was not transferred until death. However, the results indicated that when a beef farmer destocks and retains payments, they will also qualify for a State pension, thus they are marginally better off financially than farming at an average stocking rate. This finding is problematic as it illustrates that farm payments are not encouraging older farmers to facilitate earlier entry of younger farmers. This is only heightened by the fact that some farmers have no source of retirement income once they transfer the farm to a successor, thus the retention of a steady retirement income from farming is enticing for older farmers.

For dairy systems, the farm is capable of producing enough income for both the farmer and their successor should they take over control of the farm. While a dairy system would have a reduced income as a result of destocking, the farmer would benefit from decreased labour requirements. Reducing stocking rate is often indicative of the management behaviour of older farmers.

Entering a period of semi-retirement could be a viable option for farmers on farms with higher incomes. Development of policy to cater for the range of farm systems and income levels would be a positive step towards increasing land mobility and, consequently, the number of young farmers in the sector. However, the other instrumental factors associated with transfer of farm management/ownership must be considered in tandem with the economic concerns.

Conclusions

In the absence of a strong policy incentive, the average age of farmers may continue to rise resulting in a stagnant land market and an agricultural sector that does not meet contemporary demands. The main focus, to date, has been on encouraging young farmer entry by various incentives, but older farmer exit has received little attention. This article highlights some of the key points outlined in a full length article published in *Land Use Policy* entitled 'Policy drivers of farm succession and inheritance' (Leonard *et al.*, 2017).

Acknowledgements:

This research was funded by the Teagasc Walsh Fellowship Programme and the Royal Dublin Society.

This work was supervised by Cathal O'Donoghue, Dean of Arts, NUI Galway, who contributed significantly to this work in his role as PhD supervisor.

References:

Leonard, B., Kinsella, A., O'Donoghue, C., Farrell, M. and Mahon, M., 2017. Policy drivers of farm succession and inheritance. *Land Use Policy*, 61, pp.147-159.

Matthews, A., 2014. 'The Agri-Food Sector', in O'Hagan, J., and Newman, C. (eds.) (2014) *The Economy of Ireland: National and Sectoral Policy Issues*, 12th Edition, Gill and Macmillan: Dublin.

Consumers' views on genetically-modified potatoes

Fiona Thorne,
Senior Research Officer, Rural Economy and Development Programme, Teagasc
Ewen Mullins,
Senior Research Officer, Crops, Environment and Land Use Programme, Teagasc
Michael Wallace,
Lecturer, School of Agriculture, Food and Rural Development, Newcastle University, UK (not pictured)
Sean Fox,
Professor of Agricultural Economics, Kansas State University, USA (not pictured)

Correspondence:
fiona.thorne@teagasc.ie

Is an Irish market for genetically-modified (GM) potatoes possible? Teagasc researchers investigate the view from the consumer perspective.

The perceived concerns around the availability of GM foods within Europe remain a subject of discussion for consumers. A Eurobarometer Survey carried out in Ireland in 2010 showed that only 37% of respondents agreed that GM food production should be encouraged (Eurobarometer, 2010). Teagasc and University College Dublin (UCD) recently completed a project that looked at consumers' views on GM potatoes. The overall objective of the project was to develop co-existence management practices in the event that genetically modified late blight resistant (GMLBR) potatoes enter the Irish market. In Ireland, the fact that conventional potatoes get sprayed up to 15 times per growing season means the cost of chemical control (Haverkort *et al.*, 2008) provides an economic rationale for the need for alternatives to be considered. This was a multidisciplinary project with researchers from the fields of crop genetics, agronomy and economics.

Given the uncertainty that exists regarding the potential demand for GM food products, a work package within the project was developed to gain an understanding of the likely consumer demand for GMLBR potatoes should they be introduced to the market.

Price point

Previous research, which has been conducted on the pricing of GM foods, such as valuation studies by Boccaletti and Moro (2000) and Burton and Pearse (2003), suggest that there is significant resistance to GM foods compared to conventional and organic foods; with conventional and organic foods being successfully priced at a premium compared to GM foods. However, the literature also indicates that GM foods can gain reasonable market shares if priced lower than conventional and organic foods. The majority of studies to date have assumed a negative consumer reaction to GM foods and have not taken

into account the possible positive reaction that some consumers may have (Thorne *et al.*, 2016). Only a small number of GM potato-pricing studies have been conducted (Loureiro and Hine, 2002; Huffman *et al.*, 2003; Rousu *et al.*, 2003; Curtis and Moeltner, 2007). The results of these studies estimate that consumers are willing to pay a premium for non-GM potatoes of between 5% and 17%.

Experimental auctions

Market research was conducted in the Irish market in late 2009 to investigate the willingness of Irish consumers to pay for GM potato products. This research used a technique called experimental auctions, which is a relatively new technique in the market research literature. An experimental auction is a stated preference method used to illicit values for non-market goods. Auctions illicit 'Willingness To Pay' (WTP) or 'Willingness To Accept' (WTA) values from respondents for a given product. Our auction has been adapted to include both WTP and WTA bids to reflect the possible differences in consumer preference for GM potatoes.

To complete the study, respondents were given a bag of conventional potatoes and participated in an auction to exchange that bag for a bag of GM potatoes. If the respondent had a preference for the GM product, they submitted a positive WTP bid in the auction and if they had a preference for the conventional potatoes they submitted a negative WTA bid. Experimental auctions were conducted in five locations across Ireland with 147 people participating in the study. Each auction process in each location had three rounds of bidding to simulate the marketplace. The results of the second bidding across all auction sites are reported in Figure 1, which is common practice in experimental auction reporting.

In the second bidding round, 14% of the subjects submitted a positive bid indicating a preference for GM potatoes, while 12% bid zero indicating that they valued the GM and conventional potatoes equally. Of the remaining subjects, 22% of the sample bid an amount between -€0.50 and zero. If we assume that a bid of -€0.50 implies a value of €2 for GM potatoes (subjects had been told that the price of the conventional potatoes was €2.50). For a subject bidding zero for an exchange, we can infer that their valuation for GM potatoes is also €2.50. In the same way, a bid of -€1 implies a value of €1.50 for the GM potatoes, the bids in the second bidding round suggest that if GM potatoes were priced at a 20% discount to conventional potatoes (€2 vs. €2.50), they would be chosen by up to 48% of our subjects.

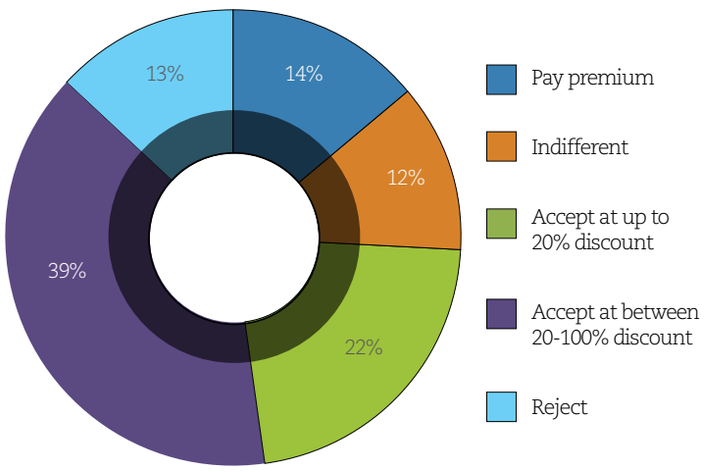


Figure 1. Demand for GMBLR potatoes.

Implications for GM food products

In conclusion, this research shows that consumer opinion remains divided on the GM food issue. The results of the experimental auction in the Irish food market has shown that there is both a preference market for GM potatoes and a segment of the population willing to accept GM potatoes at a discount to conventional potatoes. According to a Teagasc poll of Irish potato producers, 60% of those surveyed would be willing to grow GMLBR potatoes if the new crop provided them with increased returns (O'Brien and Mullins, 2007). Significant proportions of both farmers and consumers are willing to produce and purchase GM foods. The results from this research are a timely and positive contribution to the ongoing debate around GM food products, which is surrounded with uncertainty.

Acknowledgements

This research was undertaken by Teagasc and UCD as part of a Department of Agriculture, Food and the Marine Research Stimulus-Funded project (DAFM RSF 07 352) entitled 'Enhancing management practices to maintain the sustainability of current potato systems'.

References

Boccaletti, S. and Moro, D. (2000) 'Consumer Willingness-to-Pay for GM Food Products in Italy'. *AgBioForum*, 3 (4): 259-267.

Burton, M. and Pearse, D. (2003) 'Consumer Attitudes towards Genetic Modification, Functional Foods, and Microorganisms: A Choice Modeling Experiment for Beer'. *AgBioForum*, 5 (2): 51-58.

Curtis, K. and Moeltner, K. (2007) 'The Effect of Consumer Risk Perceptions on the Propensity to Purchase Genetically Modified Foods in Romania'. *Agribusiness*, 23 (2): 263-278.

Eurobarometer. (2008) *Eurobarometer 73.1: Biotechnology*, Brussels: European Commission. Available online: http://ec.europa.eu/public_opinion/archives/ebs/ebs_341_en.pdf

Eurobarometer. (2010) *Special Eurobarometer Biotechnology Report*. Available online: http://ec.europa.eu/public_opinion/archives/ebs/ebs_341_en.pdf

Haverkort, A. J., Boonekamp, P.M., Hutten, R., Jacobsen, E., Lotz, L.A.P., Kessel, G.J.T., Visser, R.G.F. and van der Vossen, E.A.G. (2008) 'Societal Costs of Late Blight in Potato and Prospects of Durable Resistance Through Cisgenic Modification'. *Potato Research* 51(1): 47-57.

Huffman, W.E., Shogren, J.F., Rousu, M. and Tegene, A. (2003) 'Consumer Willingness to Pay for Genetically Modified Food Labels in a Market with Diverse Information: Evidence from Experimental Auctions'. *Journal of Agricultural and Resource Economics*, 28: 481-502.

Loureiro, M.L. and Hine, S. (2002) 'Discovering Niche Markets: A Comparison of Consumer Willingness to Pay for Local (Colorado-Grown), Organic, and GMO-Free Products'. *Journal of Agricultural and Applied Economics* 34: 477-487.

O'Brien, M. and Mullins, E. (2007) 'Are farmers willing to grow GM potato?' Survey conducted at the National Potato Conference, Maynooth, February 14.

Rousu, M., Huffman, W.E., Shogren, J.F. and Tegene, A. (2003) 'Should the United States Regulate Mandatory Labeling for Genetically Modified Foods? Evidence from Experimental Auctions'. Working Paper, RTI International, Raleigh, NC, USA.

Thorne, F., Fox, J.A., Mullins, E. and Wallace, M. (2016) 'Consumer Willingness-to-Pay for Genetically Modified Potatoes in Ireland: An Experimental Auction Approach'. *Agribusiness*: doi:10.1002/agr.21477.

Events

2017
JANUARY

January, multiple dates and locations

CalfCare events

Teagasc, Animal Health Ireland and Volac, with the support of a number of milk processors, will jointly deliver a nationwide series of 14 CalfCare events during January. The focus of these events is to remind farmers of the key essentials in the care of their calves from birth and refresh their skills before the spring calving season.
www.teagasc.ie and www.animalhealthireland.ie

January and February, venues tbc

Nationwide series of Spring Tillage Seminars

The tillage industry is going through some difficult times with low grain prices and increasing costs. These seminars will address how farmers can target costs and increase outputs. The discussion will include information on the latest varieties, details of the TAMS scheme (if launched) and management hints for the spring. Teagasc advisors, specialists and guest speakers will be available at the seminars. All are welcome.
Contact: ciaran.collins@teagasc.ie www.teagasc.ie/news--events/

January and February, venues tbc

Regional series of winter crop walks

Getting the early spring management of winter cereals is very important to sustain high yields later in the season. These crop walks will hear from Teagasc experts who will examine the agronomy needed for the major crops for the coming season. Winter barley management will be to the fore with tiller management and early nitrogen strategies discussed. The meetings will feature tillage specialists and advisors with input from leading researchers.
Contact: ciaran.collins@teagasc.ie www.teagasc.ie/news--events/

January 11-14 *RDS, Dublin*

Teagasc at the BT Young Scientist & Technology Exhibition

Visit the Teagasc stand in the 'World of Science and Technology' zone where the theme is 'Teagasc Technology Foresight 2035'. The exhibition is the final stage in the competition, which is open to all second-level students from Ireland, both north and south. As well as the student projects on display, there are a further four exhibition halls filled with science and technology-based exhibits and entertainment, making it a thrilling event for those who entered and for general visitors too.
Contact: catriona.boyle@teagasc.ie http://btyoungscientist.com/

January 26 *Lyrath Estate Hotel, Kilkenny*

National Tillage Conference

The conference will look at the short- and long-term market prospects for tillage products, as well as provide an update on the latest research findings for the upcoming season.
Contact: eleanor.butler@teagasc.ie

January 31 *Landmark Hotel, Carrick on Shannon, Leitrim*
February 2 *Dolmen Hotel, Carlow*
February 8 (hill sheep) *Venue tbc, Co Kerry*

National Sheep Conference

The latest sheep research and advice will be presented at these regional events.
Contact: michael.diskin@teagasc.ie

FEBRUARY

February, multiple dates and locations

Spring grass seminars

Teagasc will deliver a series of nationwide farm walks to highlight the benefits of including spring grass in the diet of all livestock – dairy, beef and sheep. These farm walks will highlight how early turnout and the use of proven grazing technologies will increase performance and reduce costs on livestock farms.
Contact: tom.odwyer@teagasc.ie www.teagasc.ie/news--events/

February, date tbc *Teagasc Ashtown Food Research Centre*

From BioÉire visions to actions

As part of the 'Bioeconomy Impact Series,' the BioÉire team at Teagasc are delighted to announce this one-day design thinking workshop bringing together invited policy, research and support agency stakeholders to discuss and delineate their roles, actions and influences in progressing a national bioeconomy action plan for Ireland.
Contact: laura.devaney@teagasc.ie or maeve.henchion@teagasc.ie

February 21-22 *London, UK*

CommBeBiz - Bioeconomy Impact 2017: Research to Innovation

The popular CommBeBiz annual event is designed to challenge, support and inform researchers on their quest to innovate in the commercial, social and policy arenas. Through keynote speakers and workshops, the event will aim to enhance key skills (social media, IPR, PR, funding, etc.) needed for the innovation process and provide a valuable networking opportunity and insights into innovation success stories and stumbling blocks in the bioeconomy.
Contact: aine.regan@teagasc.ie or maeve.henchion@teagasc.ie

February 28 *Teagasc Ashtown Research Centre, Dublin 15*

Seminar - Grow Safe

Microbiological aspects of safe horticulture/food production with a special emphasis on water.
Contact: stephen.alexander@teagasc.ie www.teagasc.ie/news--events/

MARCH

March 1 *Teagasc Ashtown Research Centre, Dublin 15*

Top Fruit Seminar

An apple producer event to highlight orchard nutrition and changes to the 2017 spray programme.
Contact: dermot.callaghan@teagasc.ie

March 22 *Dublin, location tbc*

Septoria Conference

This conference will update the industry on the latest position on septoria-fungicide resistance and outline effective and sustainable disease control programmes with international experts.
Contact: eleanor.butler@teagasc.ie

APRIL

April 24 (Cavan) and April 25 (Moorepark)

Pig Research Dissemination Days

These events will feature the broad array of research projects currently ongoing in Teagasc's Pig Development Department. The event will provide attendees with the most up-to-date research results and the opportunity to meet with researchers and postgraduate students.
Contact: ciaran.carroll@teagasc.ie

April 27 *Teagasc Ashtown Research Centre, Dublin 15*

Horticulture Technology Conference

This one-day, grower-focused event will update the growers on advances in horticultural technologies, such as lighting, protected structures and crop protection.
Contact: michael.gaffney@teagasc.ie www.teagasc.ie/news--events/

JUNE

June 28 *Teagasc Crops, Environment & Land Use Research Centre, Carlow*

Crops and cultivations - Oak Park Open Day

An opportunity to view and discuss the crop research experiments at Oak Park, as well as machinery stands and live cultivation demonstrations.
Contact: eleanor.butler@teagasc.ie

For a list of Teagasc's food industry training schedule (food safety, food law, animal welfare, quality assurance, microbiology, cheese making, calculating meat content, laboratory auditing) please see: http://www.teagasc.ie/food/research/training/schedule.asp
For presentations from previous Teagasc events see: http://www.teagasc.ie/publications/