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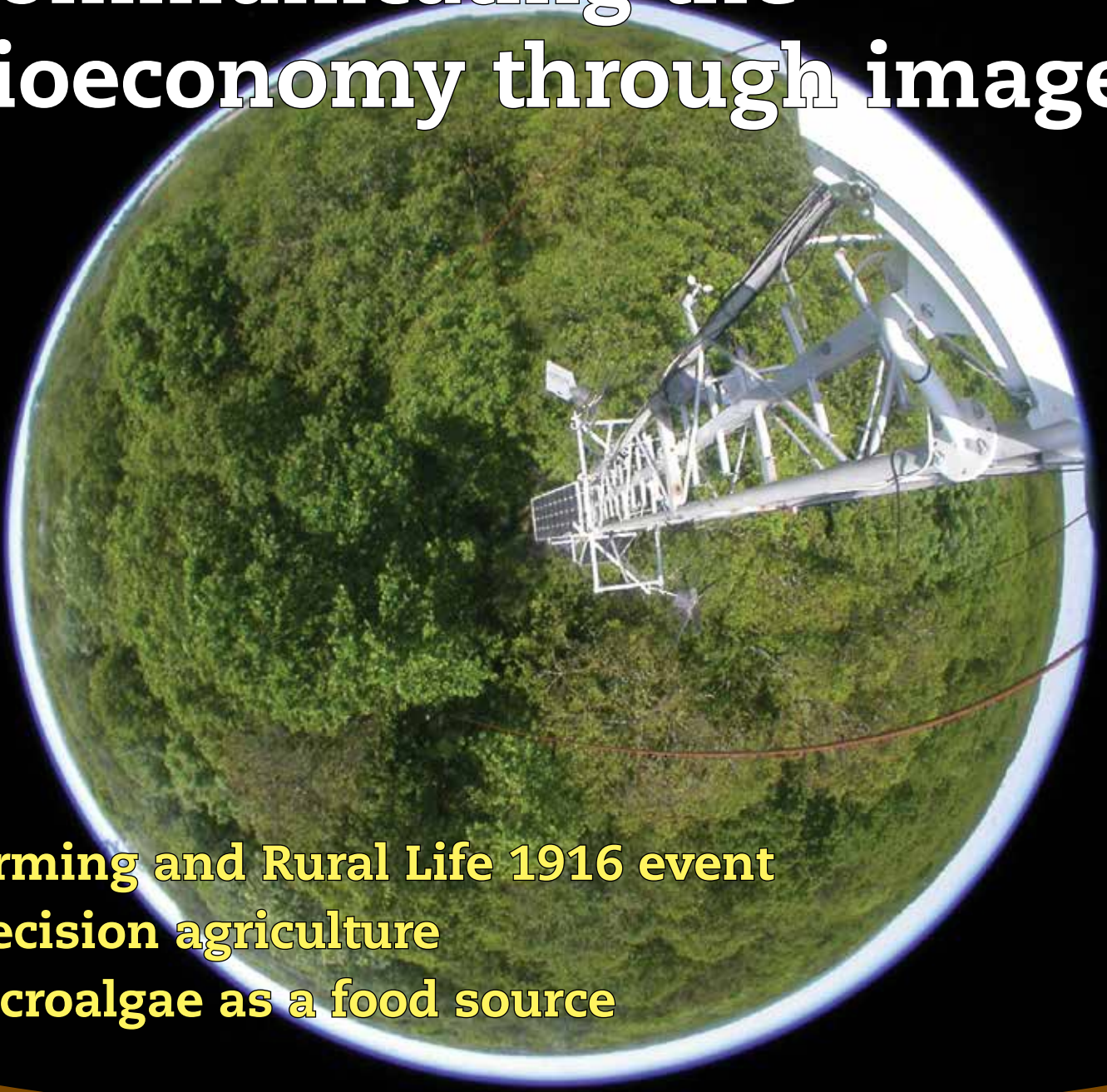
# Research

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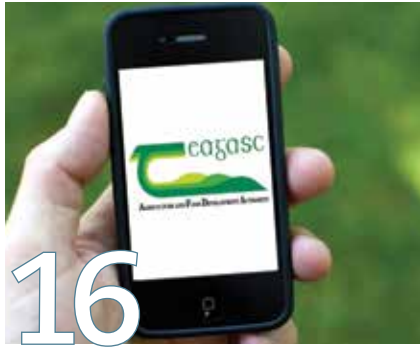
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## Communicating the bioeconomy through images



**Farming and Rural Life 1916 event**  
**Precision agriculture**  
**Microalgae as a food source**

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Teagasc | Oak Park | Carlow



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Cover photo: Matthew Wilkinson's image 'Alice Holt Forest Phenology' winner of the CommBeBiz photography competition.



## Farming and Country Life 1916

The Farming and Country Life 1916 event takes place at Mellows Campus, Athenry, Co Galway on June 10 to 11, 2016, to commemorate the 1916 Easter Rising and to reflect on developments in farming and country life over the last century. The event is being organised by Teagasc in partnership with Galway County Council. A large number of farming, rural, community and voluntary, local and national organisations, along with many local societies, will participate.

This event forms part of the official Ireland 2016 Centenary Year celebrations. The role of women in the Rising, farming, and country life in 1916 will be at the forefront of what will be a high-quality educational, authentic representation that will accurately retell the story of local 1916 military events and farming and country life of the era. It is planned to showcase a significant number of interactive exhibits, dramatic re-enactments, lectures and reconstructions.

There will be a series of highly interactive villages that will explore all aspects of farming and country life in Ireland 100 years ago and will chart the major developments in the first half of the 20th century. The event is organised into seven thematic villages:

- Ireland 1916 – The Rising.
- Farm Family, Rural Life and the Role of Women.
- The Land.
- Education and Cooperation.
- Mechanisation of Farming.
- Livestock.
- Sporting and Cultural Life.

In planning this event we are guided by the following principles:

- To commemorate the Easter Rising and to reflect on developments in farming and country life over the last century in a holistic manner combined with a strong commitment to the development of a comprehensive and balanced programme of events over the two days.
- Recognition of the totality of the history of the period, and all of the diversity that this encompasses, while promoting active engagement with those interested in commemorating our history, in all its dimensions, with pride and respect.
- To secure the participation of local communities and people of all ages.

If you would like to get involved please contact our event email at [1916@teagasc.ie](mailto:1916@teagasc.ie).



**Michael G. Diskin,**  
Chairperson, Organising Committee



**Cathal O'Donoghue,**  
Head, Rural Economy and Development Programme  
Convenor Land Village

## Feirmeoireacht agus Saol na Tuaithe 1916

Beidh an t-imeacht Feirmeoireacht agus Saol na Tuaithe 1916 ar siúl ag Campas Uí Mhaoilíosa, Baile Átha an Rí, Co. na Gaillimhe, an 10 agus an 11 Meitheamh 2016, agus é mar aidhm leis Éirí Amach na Cásca 1916 a chomórath agus machnamh a dhéanamh ar fhorbairtí san fheirmeoireacht agus i saol na tuaithe thar an gcéad bliain seo a chuaigh thart. Tá an t-imeacht á eagrú ag Teagasc i gcomhpháirt le Comhairle Contae na Gaillimhe. Beidh líon mór eagraíochtaí páirteach ann – idir eagraíochtaí feirmeoireachta, eagraíochtaí tuaithe, eagraíochtaí pobail agus deonacha agus eagraíochtaí áitiúla agus náisiúnta – in éineacht le cuid mhór cumann áitiúil.

Tá an t-imeacht mar chuid de cheiliúradh oifigiúil Bhliain Comórtha Céad Bliain Éire 2016. Is ar ról na mban san Éirí Amach, san fheirmeoireacht agus i saol na tuaithe sa bhliain 1916 a dhíreofar go sonrach san imeacht, rud a bheidh ina fhíorléiriú oideachasúil ar ardchaighdeán ina n-inseofar an athuair scéal na n-eachtraí míleata sa bhliain 1916 agus scéal na feirmeoireachta agus scéal shaol na tuaithe le linn na tréimhse sin. Tá sé beartaithe líon suntasach de thaispeántais idirghníomhacha, d'athléirithe drámata, de léachtaí agus d'athchruthuithe a thaispeáint. Beidh sraith sráidbhaile an-idirghníomhach ann freisin, áit a ndéanfar iniúchadh ar gach gné den fheirmeoireacht agus de shaol na tuaithe in Éirinn 100 bliain ó shin agus a sonrú na mórforbairtí a bhí ann sa chéad leath den 20ú haois. Beidh an t-imeacht eagraithe ina sheacht sráidbhaile théamacha:

- Éire 1916 - An tÉirí Amach
- Teaghlach Feirme, Saol na Tuaithe agus Ról na mBan
- An Talamh
- Oideachas agus Comhoibriú
- Meicniú na Feirmeoireachta
- Beostoc
- An Saol Spóirt agus Cultúrtha

Agus an t-imeacht seo á phleanáil againn, tugaimid aird ar na prionsabail seo a leanas:

- Éirí Amach na Cásca a chomórath agus machnamh iomlánaíoch a dhéanamh ar fhorbairtí san fheirmeoireacht agus i saol na tuaithe thar an gcéad bliain seo a chuaigh thart, in éineacht le tiomantas láidir do chlár imeachtaí atá cuimsitheach agus cothromaithe a fhorbairt don dá lá.
  - Aitheantas a thabhairt d'iomláine stair na tréimhse, agus don éagsúlacht ar fad a ghabhann léi, agus rannpháirtíocht ghníomhach a chur chun cinn ag an am céanna le gach duine a bhfuil spéis acu inár stair agus i ngach gné di a chomórath ar bhealach bródúil agus measúil.
  - Rannpháirtíocht pobal áitiúil agus daoine de gach aois a dhaingniú.
- Más mian leat bheith páirteach le imeacht Feirmeoireacht agus Saol na Tuaithe 1916 cuir réamphoist chuig [1916@teagasc.ie](mailto:1916@teagasc.ie)

**Michael G. Diskin,**  
Cathaoirleach,  
an Coiste Eagraithe

**Cathal O'Donoghue,**  
Ceann, Clár an Gheilleagair  
Áitiúil agus na Forbartha Áitiúla  
Tionólaí an tSráidbhaile Talún

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### Mark McGee

Mark McGee is a senior research scientist in the Livestock Systems Department at the Teagasc beef research centre, Grange, Co Meath. He has an honours degree in agricultural science from University College Dublin (UCD). The research focus for his PhD was suckler beef cow (and calf) nutrition, immunology and physiology. After finalising his PhD in 1997 he subsequently spent five years working in the agri-food industry, in a technical capacity. During this time he also successfully completed a diploma in advanced management and an executive MBA from UCD Michael Smurfit Graduate School of Business.

At the end of 2002, he returned to research in Grange, on a contract basis, leading a new programme on the feeding and nutrition of beef cattle. This research focused on rumen digestion and nutrient supply from forage-based diets, and strategies for optimal utilisation of nutrients consumed by cattle. In 2005, he took on a permanent position there, initially working in the area of feed efficiency within grass-based suckler beef production systems. His current areas of research include: feed efficiency – residual feed intake; beef cattle nutrition and feed evaluation; influence of dietary factors on nitrogen partitioning; genotype and nutritional effects on beef heifer puberty; grass-based suckler-bred male beef production systems; and calf passive immunity and health. He presently leads a large Department of Agriculture, Food and the Marine (DAFM), Research Stimulus Fund (RSF) project, *IdentiFEED-13/S/519*. Additionally, he is a work-package leader within five further DAFM RSF-funded projects and is also actively involved in other research programmes at the centre. Mark has been the principal supervisor to completion of four PhDs plus two MAgSc students and a co-supervisor of seven other post-graduates. He is currently principal supervisor to four PhDs and one MAgSc, as well as overseeing a post-doctoral researcher and co-supervising several other post-graduates. He was an associate editor of the *Teagasc Beef Manual* and was chairperson of the *Agricultural Research Forum* in 2013 and 2014.

He is a member of the editorial board of the *Journal of Animal and Feed Sciences* and regularly acts as a reviewer for international scientific journals. He has published extensively, including (co)-authoring 65 peer-reviewed scientific papers, on various aspects relating to beef cattle production.

Originally from Co Mayo, Mark is now living in Trim, Co Meath, and his personal interests include running, cycling and reading.

## Tech revolution in Irish agriculture

The Teagasc ICT Agri Seminar was held in Dublin recently. Speaking at the seminar, Gerry Boyle, Director of Teagasc said: "Information and communication technology and digital technologies have transformed many sectors of our economy and of our lives, from transport, logistics and manufacturing to music and books. The same potential exists in the agriculture sector. Digital technologies for sensing, analytics and automation are some of the key emerging technologies with the potential to revolutionise the future of Irish agriculture. Already, some of that potential is being realised, as shown here. But this is only a taster of what could be achievable in the future."

The event brought together end users, industry, research performers and research funders, to identify state-of-the-art technologies currently in use, to address upcoming challenges and look to future opportunities.

For more on the seminar, see pages 16-17.



Pictured at Teagasc's ICT in Agriculture Seminar are (from left): Professor Gerry Boyle, Director of Teagasc with Richard Howell, Department Of Agriculture, Food and the Marine, John Bell, European Commission and Director of Research, Teagasc, Frank O'Mara.

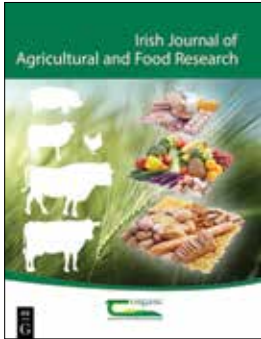
## Soil fertility trends

Over the last 10 years Teagasc has analysed approximately 38,500 soil samples annually for its farmer clients. These samples provide an insight to national soil fertility trends (soil pH, phosphorus [P] and potassium [K] for each farming sector). Overall soil test results for 2015 show that approximately 90% of samples have sub-optimal fertility status (soil pH <6.3, P & K index 1 or 2), a situation that has persisted for the last number of years. Mark Plunkett, Teagasc Soil and Plant Nutrition Specialist, said: "This is a serious limitation to the production potential of our soils and limits our ability to maximise our most competitive advantage in the market place, which is our ability to grow high yields of quality grass." Currently, 64% of grassland soils and 45% of tillage soils have below the optimum soil pH (i.e., pH 6.3 for efficient grassland production and pH 6.5 for tillage crops).

A major concern emerging from these soil test data is the continuous decline in soil P levels over the last decade with the majority of both grassland (61%) and tillage (59%) farms having suboptimal P fertility (i.e., P index 1 or 2). Although fertilizer P usage has recovered somewhat from its lowest level in 2008-2009, it appears that the levels of current usage are not balanced with P off-takes on many farms. Approximately 50% of grassland and tillage soils have low K fertility levels (54% and 47% respectively). However, soil K trends show a stabilisation or gradual improvement over the last five years. This may be due to better distribution of manures on grassland farms and the targeting of higher K compound fertilizers on tillage farms.

This soil fertility information is summarised by county and by farming enterprise and can be found at: <http://www.teagasc.ie/soil/analysis/results.asp>

## IJAFR opens access to all



Teagasc's peer-reviewed *Irish Journal of Agricultural and Food Research* has gone fully online, with open access bringing it in line with top international standards in academic publishing. The journal will be using the Editorial Manager (Aries) submission and tracking system, papers are freely available online and will be distributed digitally by DeGruyter Open to indexing and abstracting databases and thousands of libraries worldwide. Papers are plagiarism-checked and references are live-linked using CrossRef/Web of Science. The editorial committee welcomes relevant submissions. Readers can sign up for e-TOC alerts and also share papers via social media. See: <http://www.degruyter.com/view/j/ijafr>

Back issues of the journal to 1961 are available on the digital preservation service JSTOR [www.jstor.org](http://www.jstor.org) (also incorporating: *Irish Journal of Agricultural Research*; *Irish Journal of Agricultural Economics and Rural Sociology*; and, *Irish Journal of Food Science and Technology*).

## National tillage crops conference

Yield, grain prices and costs of production determine the profitability of tillage enterprises. The achievement of high yields and cost of production are in the hands of the growers. That was the message from the Teagasc National Tillage Crops Conference in Kilkenny. John Spink, Head of Crops Research in Oak Park, said: "Growers have little control over grain prices in the short term; however, in the longer term, the development of higher value markets for Irish tillage products is an objective of the *FoodWise 2025* development strategy for Irish agriculture. Growers have direct influence on crop yields and the cost of production through the decisions they make."

The conference focused on the technical improvements farmers can make on their own farms. Teagasc Crops Researcher, Joseph Lynch, outlined yield formation in winter wheat and the need to focus on maximising final ear number and prolonging grain filling to achieve high yields in Irish conditions. Dermot Forristal, Teagasc Crops Researcher, spoke about the importance of crop rotation to maximise cereal yields, the profitability of the whole rotation and controlling costs. He also identified the most viable non-cereal break crops for Ireland based on the recent Department of Agriculture, Food and the Marine funded CROPQUEST project. John Carroll, Teagasc Crops Researcher, continued the theme of break crops, by outlining the work on optimising bean production in the Teagasc/IFA grain levy funded break crops programme.

Sarah Cook, of ADAS in the UK, outlined the mistakes made in England that allowed grass weeds to reach



John Carroll, Research Officer, Teagasc Crops, Environment and Land Use Research Programme; Ivor Deverell, farmer, Offaly; and, Paddy Browne, Head of Teagasc Crops, Environment and Land Use Research Programme.

epidemic proportions and advised on what steps Irish growers could take to keep grass weed populations at manageable levels.

The development of insensitivity, or resistance, to fungicides in *Septoria* has been an ongoing issue for more than a decade. Teagasc Crops Researcher, Steven Kildea provided an update on the results of the *Septoria* sensitivity monitoring and the discovery last autumn of resistance to the succinate dehydrogenase inhibitor (SDHI) group of fungicides. He also gave advice for the coming season on how to slow the development of this resistance and stressed the importance of the whole industry complying with anti-resistance guidelines for future sustainability.

The proceedings from the conference can be viewed at: [http://www.teagasc.ie/publications/view\\_publication.aspx?publicationID=3861](http://www.teagasc.ie/publications/view_publication.aspx?publicationID=3861)

## New MTL CEO



John Hunter has been appointed the new CEO of Moorepark Technology Limited (MTL). He joins the company from Tipperary Co-op, where he was assistant general manager.

MTL is a joint venture between Teagasc and nine dairy processing companies. It has a modern versatile pilot plant facility based on the Teagasc campus in Fermoy, where John will be based. It offers a variety of services, including pilot plant rental and technical assistance, contract R&D and pre-commercial manufacture. Its mission is to stimulate and enhance market-led research and development in the Irish dairy industry.

Congratulating John on his appointment, Head of the Teagasc Food Research Programme, Mark Fenelon, said: "John will have a key role to play in implementing the MTL strategy for development and growth, which includes a €10 million capital investment over the next two years."

## Hybrid ryegrass varieties

A European consortium of researchers from Ireland, the UK, Denmark and Switzerland has uncovered the gene at one of the two main genetic regions that confer self-incompatibility in perennial ryegrass, the major forage grass in Ireland. Self-incompatibility is a genetic mechanism used by plants to avoid self-fertilisation and promote outcrossing. This research work has been reported in the scientific journal, *Molecular Biology and Evolution*. Research collaboration over the last 10 years of this consortium used a genetic fine-mapping approach to identify the male component of one of the regions, known as the S region (the other is Z), and provided multiple evidence that an LpSDUF247 gene is involved in its determination. Susanne Barth, Teagasc Research Scientist, Crops, Environment and Land Use Programme, Oak Park, Carlow, said: "Knowing the genetic nature of one of the two main determinants will enable us to now work towards more directed hybrids making use of the S and Z self-incompatibility system." She added: "This strategic research has been supported by Teagasc over the last decade by enabling two postgraduate students under the Teagasc Walsh Fellowship scheme to complete their PhDs on self-incompatibility and characterisation of the S and Z regions in perennial ryegrass." The published scientific report can be read at: <http://mbe.oxfordjournals.org/content/early/2015/12/09/molbev.msv335.full.pdf+html?sid=d5437d0c-6cfd-4a8d-a133-b51acd911e34>

## Microbiome conference

Attendees at a microbiome-based Foods for Health and Sustainability workshop in Brussels heard how the next generation of functional food and feed will be directed towards the microbiome to improve health, drive food production and support a more sustainable agriculture.

The workshop was hosted by the APC Microbiome Institute, the Irish research institute for diet, medicine and the microbiome. APC is a partnership between University College Cork and Teagasc, the Agriculture and Food Development Authority. It is funded by Science Foundation Ireland and industry partners. Since its establishment in 2003, APC scientists have related food and microbial diversity with health, discovered new anti-microbials and anti-inflammatories and developed templates for future foods.

Speakers at the workshop highlighted the effects of dietary and lifestyle choices on food demands and the challenges faced by production systems in relation to food nutritional security and sustainability. Furthermore, the relevance of the microbiome and its associated transformative technologies to the food value chain was examined, as well as their potential to boost innovation for societal and economic impact for Europe.

## Health benefits of potatoes

Bord Bia, in conjunction with the Irish Farmers' Association and the Irish Potato Federation, launched an EU and industry-funded, three-year promotional campaign for potatoes, 'Potatoes: More Than A Bit On The Side', which aims to increase the consumption of potatoes and specifically targets 22 to 44-year-old females.

Lorcan Bourke, Sector Manager for Potatoes at Bord Bia, said: "This collaborative initiative will see potatoes presented as a naturally fat and gluten-free ingredient, that can be used in many different ways and for a variety of occasions, to positively change the perception of younger consumers about potatoes and show that they are indeed, as the campaign name highlights, more than a bit on the side."

## Communicating the impact of research



Pictured are (from left): Rhonda Smith, Minerva Communications UK Ltd.; Rob Peters, European Commission; Dirk Carrez, Biobased Industries Consortium; Maeve Henchion, Teagasc; and Gerry Boyle, Director of Teagasc.

At the recent CommBeBiz Bioeconomy Impact 2016 conference in Dublin, researchers had an opportunity to think critically about their work and consider how they can effectively utilise it to deliver greater impact.

The programme included expert keynote speakers and workshops designed to build and enhance the capacity and skill of researchers, particularly in identifying opportunities for creating impact and outreach. Activities such as a networking wall and a workshop on research impact statements gave attendees an all-round introduction to the skills they need to create impact with their research.

Matthew Wilkinson was announced the winner of the CommBeBiz photographic competition for his image 'Alice Holt Forest Phenology, which features on the cover of this edition of *TResearch*. For more on the photographic competition, see pages 38-39.

## Food Works seeks food entrepreneurs

Food Works, a programme jointly run by Bord Bia, Enterprise Ireland and Teagasc, is seeking a new cohort of ambitious individuals with an interest in building an international food or drink business in Ireland.

Through a series of workshops and one-to-one mentoring, successful participants are given a range of practical business supports required to develop an initial concept into a winning food product with global export potential. The supports provided include consumer market research, business plan development, technical advice, commercial viability testing in addition to access to R&D facilities and possible investors and state funding. Over the past three years, a total of 60 start-ups from all food sectors have participated in Food Works. The Food Works team have revealed that 60% of these businesses are now trading, which is deemed extremely positive given the high rate of start-up failures within the first 12 months of launching, while 32% of them have started exporting.



Previous Food Works participants; Natalie and Karen Keane, Bean and Goose; David Carey, Nutraplenish; and Roisin Hogan, HiRo by Roisin.

## Technology transforming Irish agri-food and bioeconomy



Pictured at the Teagasc 2035 Foresight event are (from left): Banning Garrett, founding Director of the Atlantic Council's Strategic Foresight Initiative; Aidan O'Driscoll, Secretary General of the Department of Agriculture, Food and the Marine; Janet Bainbridge OBE, CEO of Agriculture Technology for the UK Trade and Investment; Noel Cawley, Chairman, Teagasc; Frank O'Mara, Director of Research, Teagasc; and Lance O'Brien, Teagasc's Head of Foresight and Strategy.

The final report of the Teagasc Technology Foresight 2035 Project was published at an international conference in the Aviva Stadium, Dublin, recently. As part of the Technology Foresight Project, over 200 experts and industry stakeholders were consulted to identify breakthrough technologies that will transform the Irish agri-food and bioeconomy sector by 2035.

Five technology themes have been identified as being the priorities for Irish research and innovation in the coming years: plant and animal genomics and related technologies; human, animal and soil microbiota; digital technologies; new technologies for food processing; and transformation in the food value chain system. The full report is available at: [http://www.teagasc.ie/publications/view\\_publication.aspx?PublicationID=3897](http://www.teagasc.ie/publications/view_publication.aspx?PublicationID=3897) and a full report will appear in the next issue of *TResearch*.

# Carbon sequestration in grassland soils

Gemma Torres-Sallan was joint-poster winner at the recent Teagasc Walsh Fellowships seminar for her work on soil carbon sequestration.

Soil organic matter has several functions in soils: it supplies nutrients in a plant-available form. It improves soil water infiltration, holding capacity and aeration, enhances soil structure and supports plant development and growth. Soil holds 3.5 times more carbon (C) than the atmosphere, and is the largest C pool after the oceans, containing 2,500 billion tonnes of C. Therefore, soils are considered a vital pool for C sequestration.

When organic matter arrives into the soil, invertebrates are responsible for physically breaking it down. Then, bacteria and fungi start to decompose it and discharge mucilage, which in turn glues the mineral fraction to soil organic matter. This process develops soil macroaggregates (>250µm). Over time, these macroaggregates break down into smaller units. These are called microaggregates (53-250µm). The coating of mineral particles around microaggregates physically protects soil organic matter, reducing both the mineralisation potential in these fractions and resultant CO<sub>2</sub> emissions to the atmosphere. Soil organic matter located in microaggregates can remain in soils for 10 to 100 years. Similarly, organic matter associated with silt and clay (<53µm) has a residence time of 100 to 1,000 years or more, and can be considered sequestered. This research has assessed C associated with large macroaggregates, macroaggregates, microaggregates and silt/clay of six dominant Irish grassland soil types, down to one metre depth.

Results show that in the first 30cm of soil, 84% of the C is located in the largest aggregate fractions. As the mean residence time of C associated with these fractions is one to 10 years, topsoil C is not suitable for long-term predictions of sequestration due to its high turnover rate.

The driving factor of aggregate formation in the top 30cm is soil organic matter. Given that most Irish grasslands contain similar amounts of soil organic matter in the top 30cm, there are no differences between soil types in terms of C storage. Nevertheless, when horizons below 30cm are analysed, two different trends are observed:

- soils with a high clay proportion have most of their C associated with smaller aggregate sizes, preventing C decomposition and the subsequent CO<sub>2</sub> emissions to the atmosphere; and,

- free-draining soils, such as brown earths, contain most of their C in bigger aggregate sizes. Therefore, these soils have less potential for C sequestration than clay influenced soils.

Differences between soil types are only evident when measured at depth and after analysing aggregate associated soil organic C. Therefore, these two factors should be taken into account in order to make accurate predictions about C sequestration in grasslands soils.

## Acknowledgements

This research is funded by the Teagasc Walsh Fellowship scheme, in collaboration with the Irish Soil Information System (co-funded by the STRIVE Programme of the Environmental Protection Agency) and AGRI-I (funded by the Stimulus Programme of the Department of Agriculture, Food and the Marine). Thanks to Rogier Schulte and Brian Reidy for their help.



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# Nitrogen fertilizer selection for cereal crops

## balancing agronomic and environmental goals



N<sub>2</sub>O sampling using static chambers.

Leanne Roche was the recipient of the Walsh Fellowship Gold Medal and Best Oral Presentation at the Teagasc Walsh Fellowship seminar for her PhD investigating nitrogen fertilizer source selection to achieve production and environmental goals in spring cereal production.

Ireland has ambitious growth targets for the agriculture sector (Food Wise 2025, Department of Agriculture, Food and the Marine) where the value of primary output is expected to increase by 65%. An increase in output will inevitably lead to an increase in the use of nitrogen (N) fertilizers. There is also European legislation that requires a reduction in gaseous emissions (greenhouse gas [GHG] and ammonia [NH<sub>3</sub>]). Therefore, mitigation strategies are required to reduce N losses from N fertilizers.

### Background

Agriculture accounts for approximately 32% of national GHG emissions and 98% of national NH<sub>3</sub> emissions. The application of N fertilizers to soils contributes to nitrous oxide (N<sub>2</sub>O) emissions. N<sub>2</sub>O is a potent GHG that is 298 times more potent than carbon dioxide. Calcium ammonium nitrate (CAN) is the dominant N fertilizer used by tillage farmers. Half of the N in CAN is in the nitrate (NO<sub>3</sub><sup>-</sup>) form, which can undergo the microbial process of denitrification and produce N<sub>2</sub>O emissions. In contrast to CAN, urea has potential to reduce N<sub>2</sub>O losses as it does not immediately contribute to the soil NO<sub>3</sub><sup>-</sup> pool. Urea is also significantly cheaper (approximately €0.75 kg/N) per unit of N than CAN (approximately €1.00 kg/N). A drawback of urea is the potential for N loss through NH<sub>3</sub> volatilisation. Minimising all N losses is important as they represent a financial loss to farmers and may negatively impact yield. Currently, the percentage of applied N estimated to be lost as N<sub>2</sub>O is calculated using a default value of 1%. This default value does not account for country specific conditions or allow agriculture to gain credit for implementing best management practice in relation to N fertilizers.

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Table 1. Grain yield, apparent fertilizer recovery and N<sub>2</sub>O emission factors for both sites and both years for 150kg N/ha applied.

N fertilizer source	Grain yield (t/ha)				Apparent fertilizer recovery (AFR) (%)				N <sub>2</sub> O emission factors (%)			
	JC		MT		JC		MT		JC		MT	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
CAN	10.62a	10.00a	7.28a	8.52a	62	60	47	63	3.20	0.11	0.49	0.21
Urea	10.64a	10.41a	7.65a	8.85a	46	52	49	57	1.69	0.33	0.31	0.23
Urea + NBPT	11.05a	10.31a	7.79a	9.06a	68	53	58	69	0.84	0.04	0.23	0.16
Urea + DCD	11.13a	10.60a	7.39a	8.66a	58	41	50	60	0.65	0.08	0.25	0.00
Urea + NBPT + DCD	10.31a	10.55a	7.05a	8.08a	44	55	46	62	0.20	0.08	0.20	0.12
Unfertilized control	6.66b	8.40b	3.57b	2.79b								

Grain yield means followed by different letters are significantly different (within sites and years) using F-protected LSD test ( $P < 0.05$ ).

### Reduce N losses and maintain or improve production

Nitrogen stabilisers (also known as inhibitors) can be added to N fertilizers to protect against N losses. These N stabilizers show potential for mitigating gaseous N losses from agriculture. There are two main types of N stabilizers; nitrification inhibitors (DCD used in this study) which regulate the NO<sub>3</sub><sup>-</sup> pool in the soil and urease inhibitors (NBPT used in this study) which slow urea hydrolysis and reduce potential NH<sub>3</sub> losses. The aims of this Walsh Fellowship study were: to assess the effect of substituting N fertilizer source (i.e., urea for CAN) on N-use efficiency and grain yield performance of spring cereal crops; to assess the potential of N stabilisers for mitigating gaseous emissions; and, to generate specific N<sub>2</sub>O emission factors (EFs) for the different N fertilizers available.

### Study design

This study took place across three growing seasons on two spring barley sites located at Johnstown Castle (JC), Co Wexford, and Marshalstown (MT), Co Wexford. These sites were of contrasting soil type, drainage type and cropping history. The MT site was long-term arable land (>20 years) on a free-draining loam. The JC site was short-term arable land (three years) on a moderately draining sandy loam. In the three years preceding this study, the JC site was



Spring barley plots at harvest.

cropped with maize and received annual applications of organic manure. A plot study was established where N fertilizer was applied at increasing total annual rates of 0, 100, 125, 150, 175 and 200kg N/ha in two application splits (30kg N/ha at planting with the balance in early-mid tillering). Daily N<sub>2</sub>O emissions were measured using static chambers (see photo previous page). The N<sub>2</sub>O EF was calculated as the total N<sub>2</sub>O emissions for each N source minus the background emissions from the control treatment, divided by the quantity of N applied. The EF was expressed as a percentage. Ammonia emissions were measured using passive shuttles, and grain yield and N uptake were measured at harvest (see photo bottom left).

### Results

There was a significant difference between sites, with the moderately drained, short-term arable site generally having higher grain yields and N<sub>2</sub>O emissions compared to the well-drained, long-term arable site (Table 1 above). This is understandable as sites with higher background soil N and poorer drainage have increased potential for denitrification and N<sub>2</sub>O loss. In terms of grain yield there were no significant differences between N fertilizer sources. Urea + NBPT had the highest apparent fertilizer recovery (AFR) in three out of four site years. Overall, N<sub>2</sub>O emissions were low except for JC in 2013. Urea + NBPT and urea + DCD had lower N<sub>2</sub>O emissions than CAN in all site years. This work also showed that urea + NBPT reduced NH<sub>3</sub> emissions by approximately 85% (84% in JC and 86% in MT in 2013) compared with using urea alone.

Grain yields and quality in spring cereal systems can be maintained regardless of the N fertilizer source applied. This study indicates that overall N<sub>2</sub>O emissions from spring barley are generally low and that the default EF of 1% overestimates the typical emissions in spring cereal systems. Switching N fertilizer source from CAN to stabilised urea is a win-win strategy for reducing N emissions to the environment while maintaining or increasing crop production.

### Acknowledgements

We acknowledge the contribution of Liz Shaw, Associate Professor, University of Reading; Patrick Forrestal and Richie Hackett, Research Officers, Teagasc; the technical and laboratory staff at Teagasc Johnstown Castle and Oak Park Research Centres; and the farmers for provision of field sites. This work was conducted under the Walsh Fellowship Programme and supported by the Research Stimulus Fund (Department of Agriculture, Food and the Marine) under the sustainable nitrogen fertilizer use and disaggregated emissions of nitrogen (SUDEN) project and the Agricultural Greenhouse Gas Research Initiative for Ireland (AGRI-I).

# Buttermilk: potential to protect from infection

Sarah Ross won a joint poster award for her work on *E. coli* at the recent Teagasc Walsh Fellowships seminar.

*E. coli* infections can lead to illnesses including diarrhoea and kidney failure (haemolytic uremic syndrome), as well as, worst case scenario, death. The devastating effects of *E. coli* infection were recently highlighted in the mass outbreaks in Germany which occurred due to contaminated sprouts. Therefore, preventing *E. coli* infections is of great importance. Traditionally, antibiotics are used to treat *E. coli* infection; however, the emergence of antibiotic resistant strains makes treating infection increasingly difficult. It is clear that an alternative method for prevention of infection is required.



## Sourcing prophylactics from bovine milk

A novel approach to prevent *E. coli* infection may be found in bovine milk. A component of bovine milk, termed milk fat globule membrane (MFGM) which is a membrane that surrounds and stabilises milk fat droplets, could be key. MFGM can be sourced from buttermilk, a dairy fraction which is produced in high quantities in the dairy industry. The MFGM is



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composed of fats and proteins, many of which contain bound sugars. We generated a milk fraction, rich in these MFGM sugars, from bovine buttermilk and characterised its components.

## Testing MFGM for anti-infective properties

The ability of a highly infectious strain of *E. coli*, serotype O157:H7, to infect human intestinal cells *in vitro* was tested in the presence and absence of the MFGM fraction. We demonstrated that the MFGM fraction could significantly reduce the ability of *E. coli* O157:H7 to infect the human intestinal cells *in vitro*. The anti-infective activity observed resulted from the MFGM fraction attaching to the *E. coli* cells, thereby preventing the bacteria from attaching to the human cells. We hypothesise that the MFGM sugars may act as decoys that mimic the receptors for *E. coli* on the human cells. In other words, the bacteria bind to the decoy (MFGM sugar) and are prevented from attaching to the true receptor (human cell), thereby reducing the threat from infection.

## Buttermilk as a functional food

Buttermilk may act as a source of anti-infective compounds that reduces the threat of *E. coli* O157:H7 infection in humans. There is potential to include this fraction as a functional ingredient in consumer products, such as in functional beverages, aiming to provide daily protection from infection. This work highlights an alternative use for buttermilk, increasing the worth of this under-valued dairy stream and, in turn, increasing the value of milk in the dairy industry as a whole.

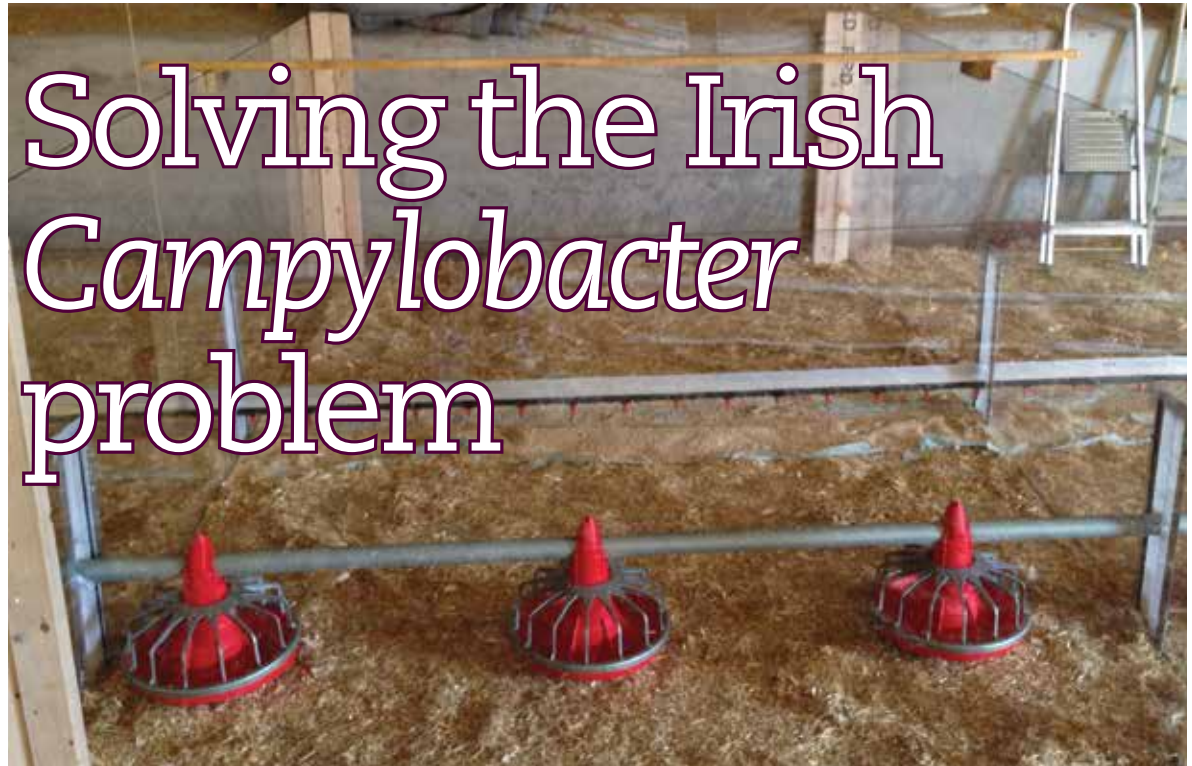
## Acknowledgements

This work was supported by the Teagasc Walsh Fellowship programme, the Department of Agriculture, Food and the Marine and the Food Institutional Research Measure. The authors would also like to acknowledge their collaborator Michelle Kilcoyne and university supervisor Lokesh Joshi from National University of Ireland, Galway.



Colorized low-temperature electron micrograph of a cluster of *E. coli* bacteria. Individual bacteria in this photo are oblong and colored brown. Photo credit: United States Department of Agriculture Agricultural Research Service.

# Solving the Irish *Campylobacter* problem



Tara Battersby won best food research presentation and the Institute of Food Science and Technology Ireland medal at the recent Teagasc Walsh Fellowships seminar.



*Campylobacteriosis* is the most common gastroenteritis in the developed world and its incidence in the EU is conservatively estimated at nine million cases per annum costing €2.4 billion (EFSA, 2011). Poultry are the primary source accounting for 50-80% of cases (EFSA, 2011). Approximately 83% of the 70 million broilers produced in Ireland each year are infected with *Campylobacter* (EFSA, 2010).



Our research discovered: vertical transmission does not occur in chickens; the environment is a potential source of *Campylobacter*; testing areas frequented by all birds (e.g., feeders and drinkers) offer an opportunity for early *Campylobacter* detection; and, once broilers are infected with *Campylobacter*, these bacteria are spread from the birds, through the ante-room to the areas surrounding the broiler house, highlighting the need for improved biosecurity. This research is being used by broiler farmers in a review of their biosecurity and, for the first time, focusing attention on preventing carriage from infected flocks out of the broiler house through the ante-room. Preventing contamination of the ante-room and outside apron would reduce the opportunity for cross-contamination of subsequent flocks. This change in emphasis away from just preventing *Campylobacter* getting into the house to include preventing the organisms getting 'out' from infected flocks will enhance control.

Our research also developed and demonstrated that a low-tech, cost effective 'biosecurity unit' such as the biosecurity cube (pictured above) could be applied to significantly improve food safety, animal welfare and productivity/profit. The research team has recently

applied for funding to transfer and extend this technology to the entirety of the broiler house on a demonstration farm, which will then be used to train farmers on preventing *Campylobacter* infection in their broiler flocks.

The project team also generated data on the growth of *Campylobacter* in a range of laboratory media, caecal contents and in broilers. This is being used to develop predictive models and inform science-based control strategies, such as the maximum time between flock testing and slaughter, logistical slaughter and single stage depopulation of broiler units.

## Acknowledgements

This project was funded by the Department of Agriculture, Food and the Marine through the FIRM programme and forms part of the Teagasc *Campylobacter* Research Programme, funded by Teagasc Internal Funding, including the Teagasc Walsh Fellowship Scheme.

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Feature



# Global food event



Ireland is to host the international World Congress of Food Science and Technology this summer.

The 18th International Union of Food Science and Technology (IUFoST) World Congress of Food Science and Technology, chaired by Teagasc's Declan Troy in his role as President of the Institute of Food Science and Technology of Ireland, will be held in the RDS from August 21-25, 2016. This prestigious event is the premier international food science and technology congress for scientists and industry taking place in 2016.

The congress will host up to 2,000 participants; including food scientists, engineers, food industry professionals, thought leaders, decision makers, regulatory authorities and students from all over the world, and presents a wonderful opportunity to showcase Ireland's world-class capability in food research and innovation. In alignment with Ireland's recent strategies, namely Food Wise 2025 and Innovation 2030, the congress will address global innovation leadership in the food industry as well as excellence in food science and technology. There will be a significant focus on how enhanced impact can be delivered through knowledge discovery and translation to industry.



- local and global food safety and security; and
- sectoral hot topics in food science and the food industry.

## Congress highlights and opportunities at a glance

- Over 80 sessions with distinguished international speakers.
- The first IUFoST-hosted Global Food Summit.
- International food industry awards; international student product development competition; and young scientist awards.
- 5k fun run and quiz bowl.
- Extensive sponsorship and exhibition opportunities.

## First Global Food Summit

IUFoST will convene the first Global Food Summit prior to the official opening of the congress. This prolific, Ministerial-level summit will be addressed by the Irish Minister for Agriculture, Food and the Marine, and brings together those who can effect strategic change to policies worldwide. The key areas that will be addressed are:

- food research prioritisation and funding;
- the global vision of the role of food science and technology in meeting societal and technological changes; and
- implementation of the global vision with national policy advisers.

## Unique networking opportunity

Online registration for the congress is now open, and great opportunities also exist for the food industry to become involved through exhibition and sponsorship. For full details, please see: [www.iufost2016.com](http://www.iufost2016.com)

For sponsorship and exhibition opportunities contact Colm O'Grady: 01 296 7524 or [colm@conferencepartners.ie](mailto:colm@conferencepartners.ie)

## Acknowledgements

The local organising committee comprises staff from Teagasc, the Food Safety Authority of Ireland, University College Dublin, Dublin Institute of Technology and University College Cork.

## Greening the global food supply chain

The theme of the congress is 'Greening the Global Food Supply Chain through Innovation in Food Science and Technology'. According to Declan Troy: "Given the increasing pressure on the global food industry with regard to sustainability, safety and health, it is appropriate for Ireland to host this most significant congress, as the agri-food industry is Ireland's largest and most critically important indigenous industry. The role of science, research and innovation in Ireland is pivotal in addressing key global challenges, and now is our time to present our work on an international platform and demonstrate our coherent approach to being a global innovation leader in this sector."

The congress theme will be addressed under distinct session topics:

- innovation in food quality and processing;
- food supply chain and distribution systems;
- future foods;
- food sustainability;
- societal challenges in nutrition and health;

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# Supporting young scientists

Jack O'Meara, a pupil at St Joseph's College, Borrisoleigh, Co Tipperary, won the Teagasc special award at the BT Young Scientist & Technology Exhibition 2016 with his project 'The Mastitis Meter' which looked at the early detection of mastitis. Pictured in Teagasc Moorepark (from left are) teacher Mary Gorey; John O'Meara; Jack O'Meara; and Gerry Boyle, Director Teagasc.  
Photo O'Gorman Photography.

## Catriona Boyle reports on the agriculture and food projects on display at the BTYSTE 2016 exhibition.



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With almost 1,200 students covering 550 student project exhibits, a buzzing exhibition hall with top companies and organisations and over 60,000 visitors, the annual BT Young Scientist and Technology Exhibition (BTYSTE) is a hive of activity and fun. Agriculture and food projects featured prominently among the exhibitions. Indeed, the overall winners of the exhibition had an agricultural theme. The top prize was awarded to transition-year students from Balbriggan, Co Dublin, who will go on to represent Ireland at the EU Young Scientist later this year. Maria Louise Fufezan and Diana Bura received the prize for their project entitled, 'An investigation into the effects of enzymes used in animal feed additives on the lifespan of *Caenorhabditis elegans*'. Commenting on the winning entry, category judge Professor Grace McCormack said: "These students have asked a novel question: "could there be any effects of enzymes added to animal feed on worms that are important for soil fertility?" The girls provide new evidence that there may be an unexpected detrimental change in behaviour and lifespan of these essential worms. The work is important for the environment and the food industry and will undoubtedly lead to further research in this important area."

Teagasc sponsors a special award at the exhibition, which went to Jack O'Meara, from St Joseph's College, Borrisoleigh, Co Tipperary. Jack's project, 'The Mastitis Meter', which was entered in the Chemical, Physical & Mathematical Sciences category, looked at the early detection of mastitis of milk in the parlour. He looked at the increased conductivity of infected milk and proposed a device that would test samples of milk for

increased conductivity before it enters the bulk tank.

Jack's award was sponsored by Teagasc for the project that best demonstrates a thorough understanding of the science of agricultural or food production, or the use of science to improve technologies available to agricultural or food production.

Teagasc Director, Professor Gerry Boyle congratulated Jack on winning the Teagasc award: "Mastitis is an issue that every dairy farmer in the country can relate to, and any new way of detecting it in dairy cows could help farmers in the day-to-day management of their cows. I would also like to congratulate all students who exhibited at the event and I was very impressed with the standards achieved in their projects."

Jack and his classmates were subsequently invited to visit both the Animal & Grassland Research and Innovation Centre and Food Research Centre at Teagasc Moorepark (see photo above). Here, they met leading researchers in both agriculture and food, and Jack presented his project to them.

Speaking of Teagasc's involvement with BTYSTE, Dr Frank O'Mara, Director of Research, said that Teagasc is proud to support the BTYSTE: "We all benefit from raising students' awareness of the importance of science, technology, engineering and mathematics (STEM) careers and the career opportunities from taking STEM courses." Visitors to the Teagasc stand met research and teaching staff and learnt about the Irish Soils Information System and Sensory Food Network Ireland.

There was an interesting array of food-related projects including: a study of an extract from honey that had incredible antibiotic activity, allowing milk to be left out of the fridge for up to seven days without souring; culturing algae and bacteria as 'space food'; and an investigation of the acceptability of human chlorophyll tattoo patches to generate our own energy sources.

# Teagasc Post-Doctoral Development Programme

In December 2014, Teagasc introduced a new Post-Doctoral Training and Development Programme (TPDP) to support its post-doctoral fellowship model. Teagasc currently has 61 post-doctoral researchers working on research projects across its four research programmes and this number is expected to increase to 100 by the end of 2016.

Undertaking a post-doctoral (PD) fellowship is an exciting time in any researcher's career. Researchers discover they have more flexibility than during a PhD, without academic constraints, and are able to dedicate their time completely to a research project, which is unlikely to happen again as their career progresses. While PD researchers have developed a valuable range of skills during their postgraduate studies, it is widely recognised that PD researchers require additional training to develop their auxiliary professional skills.

With the current economic climate, the increased interdisciplinary nature of research and the importance of science and technology, post-doctoral training needs to develop both research skills and professional competencies to ensure that PD researchers achieve success in the future and that their research delivers beneficial impact.



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## Training needs and programme framework

The Teagasc TPDP is designed to develop PD researchers' skills and performance while in Teagasc, and to equip them with a set of core competencies to enable them to undertake responsible positions as individual research leaders. This will ultimately prepare them for subsequent careers in a range of sectors (e.g., academic research, commercial research, industry). The programme has strong links with the agri-food industry, which helps to broaden participants' awareness of the requirements of employers in the agri-food industry and helps to prepare PD researchers to be ambitious and successful in their careers.

The framework for the programme is designed

## Mary Herlihy, Teagasc Post-Doctoral Research Fellow

Mary is a Post-Doctoral Research Fellow in the Animal & Bioscience Research Department at Teagasc Moorepark. She completed her undergraduate degree in Agricultural Science (specialising in Animal Science) at University College Dublin and completed her Masters and PhD in Animal Science (specialising in bovine reproductive physiology) at Teagasc, Moorepark, University College Dublin, and University of Wisconsin-Madison, USA (Teagasc Fulbright Award in Agriculture). The primary focus of her research is the genetic regulation of novel fertility traits and the investigation of nutrition/reproduction interactions in lactating dairy cows.

A fundamental element of the Teagasc Post-Doctoral Development Programme is the unique training and development component, which has proven to be a highly beneficial and innovative concept for early career scientists. Mary has completed several courses on topics including grant writing, structured PhD programme supervision, project management and leadership. Speaking about her experience, Mary said: "All these courses were run as highly interactive workshops, which were immensely educational and exceptionally insightful. I believe the training provided to me through the Teagasc Post-Doctoral Programme is an integral component in my development as a highly trained, independent scientist working within an interdisciplinary research programme, and I firmly believe that the training I have completed will greatly enhance my career development."



around four pillars each focused on developing a particular competency. Each of the modules provided under each pillar is designed and developed specifically for PD researchers by UCC and the Agri-Food Graduate Development Programme team, and the modules are delivered by experienced trainers.

A unique aspect of the programme is its flexibility and responsiveness to the needs of post-doctoral researchers. Rather than providing training that Principal Investigators or support staff think is needed, PD researchers are actively asked to feed into the programme design by identifying the skills they would like to develop.

### Courses available

The programme is uniquely tailored to the needs of Teagasc, reflecting the broader Irish agri-food context, and has the flexibility to enable PD researchers to tailor their development programme to their own needs, in consultation with their project leader. They can choose from a range of courses that are specifically designed to develop discipline-specific knowledge and research skills, professionalism and communication skills, and leadership and management skills.

Some of the courses completed to date by post-doctoral researchers include:

- writing successful grant applications;
- advanced scientific writing and presentation skills;
- media and communication skills;
- statistics and data handling;
- supervising and professional skills (mentoring/supervision);
- project management; and
- career planning and development.

### Professional Development Plans

After completing the mandatory induction programme, PD researchers complete a self-assessment of their skills and prepare a Professional Development Plan (PDP) in consultation with their project leader. The PDP is completed online and is regularly reviewed and monitored by the PD researcher and project leader to ensure the agreed development objectives are being met.

### Fellowship opportunities

Teagasc offers post-doctoral opportunities across its four research programmes: animal and grassland research; crops, environment and land use research; food research; and rural economic research. All Teagasc PD researchers participate in the development programme.

### IITD award

The Teagasc Post-Doctoral Development Programme was shortlisted for the Best Talent Management Initiative at the 2016 Irish Institute of Training and Development (IITD) national training awards.

### Acknowledgments and further details

The Teagasc Post-Doctoral Development Programme is funded by Teagasc core funding. For more details on the Agri-Food Graduate Development Programme team see: [www.agrifoodapd.ie](http://www.agrifoodapd.ie)

For information on post-doctoral fellowship opportunities in Teagasc please see: [www.teagasc.ie/opportunities](http://www.teagasc.ie/opportunities)

### Manuel Lopez Vernaza, Teagasc Post-Doctoral Research Fellow

Manuel is a Post-Doctoral Research Fellow in Ewen Mullins' research group in the Crop Science Department at Teagasc Oak Park where he is developing and expanding the potential of a new platform to genetically engineer crops called Ensifer-Mediated Transformation (EMT), which was discovered by Teagasc in 2012.

Manuel completed both his undergraduate and Master's education in plant genetics and biotechnology at the Paris Diderot University in France and he completed his PhD in plant developmental epigenetics at the University of Edinburgh. His PhD focused on the interactions between the genes leading to flowering and the environment where he successfully found that there is a common epigenetic control of floral induction, floral integration and floral organ formation in the model plant *Arabidopsis thaliana*. Following his academic studies, Manuel worked on the mechanisms to improve environmental stress tolerance in plants and microorganisms.

Manuel has participated in a number of the post-doctoral training courses on offer and said: "The post-doctoral training programme at Teagasc has allowed me, together with my supervisor, to focus on my research project through a personalised training plan for each year. I've been also able to widen my skills range through various courses in different topics such as supervision, communication skills, publishing and scientific writing."



# Targeting opportunities for ICT in agriculture

A one-day conference entitled 'Shaping the Future: Targeting Opportunities for ICT in Agriculture - Where we are now and where are we going?' was held in the Aviva Stadium, Dublin on February 26, 2016. Co-hosted by Teagasc and the ICT-AGRI ERA-NET, the conference had an attendance of 250 people, representing farmers, industry, research organisations and funding agencies from Ireland and Europe.



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## Challenges and opportunities

At the recent ICT in Agriculture seminar, Professor Gerry Boyle, Teagasc Director, set the scene by describing the challenges and opportunities that lie ahead for agriculture. Estimates predict the world will need to increase food production by 70% over 2005 levels in order to feed a world population of 9.1 billion people by 2050. Even more challenging, this has to be achieved against a backdrop of lowering greenhouse gas emissions. However, Professor Boyle also noted: "The agri-food industry in Ireland currently provides employment for 163,000 people, with food and beverage manufacturing enterprises accounting for €26 billion of total turnover."

The importance of the agri-food sector was also highlighted by keynote speaker, Dr John Bell, Director

of Bioeconomy in the European Commission. Dr Bell said that the food value chain employs one fifth of the European workforce (48 million people) and is the EU's biggest manufacturing sector. Dr Bell went on to discuss some of the weaknesses of EU research and innovation in the agri-food sector. In particular he said that it is fragmented, suffering from underinvestment, lacking a whole food-system approach and failing to capitalise on emerging trends. To address these challenges, Dr Bell gave the first preview of the European Commission's new draft plan for a Food Research Area. One of the key planks of that strategy is to make the agri-food sector 'smart' through the use of ICT.

## Big data

A key theme of the day was the emergence of 'big data' in agriculture. Professor Boyle noted: "While we already have several databases that are extensively used in agri-food and bio-economy applications, one of the key differences in this era of big data is the sheer volume of data being produced." The availability of such data, in real-time, means that "data-based decision-making will rapidly replace decisions based on gut instinct". Professor Boyle went on to say "we will, and are seeing now the democratisation of decision-making. The HIPPO – Highest Paid Person Opinion – decision-maker is being replaced by the OPO – Ordinary Person's Opinion – decision-maker. This process will see individuals, business and



communities being ultimately freed from the tyranny of the expert.”

However, Professor Boyle also sounded a note of caution, saying that the “greatest potential will derive from the ‘big data revolution’ when the subject-matter specialists work ‘hand-in-glove’ with the data/ICT experts. He said that Picasso’s jibe ‘Computers are useless. They can only give you answers’ should never be forgotten. “The focus has to be on what questions should be asked of big data.” Dr Laurence Shalloo from Teagasc picked up on this point later saying “Farmers don’t need more data - they need solutions and decision support.” Dr Shalloo said that we should “refocus precision technologies from ‘measurement because we can’, to providing holistic solutions in a real-time fashion”.

### Innovation in action

An excellent example of a farmer who has harnessed the power of data to increase profitability and sustainability is Kevin Nolan of Nolan Farms. Kevin gave a fully-costed example of the use of auto-guidance on tractors. Over 10 years, on a 500-hectare farm, Kevin was able to demonstrate savings of €156,000 using a high sensitivity auto-guidance system in comparison to manual steering. Picking up on the earlier point of democratisation of decision-making, Kevin noted that this system also allows him to delegate work to staff that would traditionally have required his direct input. Kevin is also a proponent of social media for knowledge-sharing.

The issue of farmer adoption of new technologies was another theme explored during the day. It may not be surprising that Kevin Nolan, the 2014 Farmer of the Year and former Nuffield Scholar, is a keen adopter of the latest technology, but how willing will other farmers, possibly operating at a smaller scale, be to adopt new data-driven approaches? Speakers from Farmflo, IBM, Dairymaster and Keenan Systems demonstrated, by the large uptake for their products, that where a new technology meets the need of farmers, it will be adopted very quickly. Dr John Daly, Research and Innovation Manager at Dairymaster summed it up by saying: “Farmers will adopt technology when it makes business sense and adds value to their enterprise.”

### Stronger together

Many of the speakers placed an emphasis on the importance of partnership in achieving the most from the use of ICT in agriculture. Professor Boyle described Teagasc’s involvement in the ICT-AGRI ERA-NET, adding that membership of this “grouping of research funders and leading research performers from across Europe has allowed Teagasc to tap into high-level expertise and to contribute to a European Strategic Research Agenda in this area”. He further expanded on the links that Teagasc has developed, some over many years, others more recent, with the Irish Cattle Breeding Federation, Tyndall National Institute, Waterford Institute of Technology’s Telecommunication Software and Systems Group (TSSG) and the SFI-funded Insight Centre for Data Analytics. Professor Boyle emphasised that Teagasc does not have a monopoly on expertise and it is only through the complementary groupings working together that the full power of the data-revolution will be harnessed.



Speaking in the afternoon session, Dr Kieran Drain, CEO of Tyndall National Institute, Professor Willie Donnelly, President of Waterford Institute of Technology and Professor Mark Keane of the Insight Centre described their growing interest and involvement in the agri-food area and their collaborations with Teagasc. Teagasc Director of Research, Dr Frank O’Mara, commented that Ireland has great strengths in agriculture and ICT at both a research and enterprise level, and this gives Ireland a great opportunity to be a world leader in smart agriculture for pasture-based systems.

### Research funding

Finally, the developments in this sector will depend on research and innovation, which ultimately requires funding. Dr Bell described some of the current EC initiatives at the start of the day, including a €30 million pilot scheme for smart farming and food security. The conference finished with descriptions of further funding options from Dr Iver Thysen of the ICT-AGRI ERA-NET, Richard Howell of the Department of Agriculture, Food and the Marine, and Dr Darrin Morrissey of Science Foundation Ireland. It was clear from all of the presentations that the research funding agencies see huge potential in the application of ICT in agriculture and are willing to back this with significant funding.

### Acknowledgements

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# Perennial ryegrass ploidy and clover

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Does perennial ryegrass ploidy and white clover have a role in increasing the productivity of pasture-based milk production systems in Ireland? Teagasc researchers have been investigating this question in Clonakilty Agricultural College in West Cork since 2013.

Ireland enjoys a temperate climate and the ability to grow and utilise grazed pasture over a long grazing season, providing a competitive advantage in milk production over other parts of Europe. In the post-quota era, any increase in milk production should be achieved through greater use of pasture. Perennial ryegrass ploidy has been shown to have an effect on milk production. Cows that grazed tetraploid monocultures produced more milk per cow than cows that grazed diploid monocultures (Wims *et al.*, 2012). A number of research experiments have reported that cows grazing grass-clover swards had increased dry matter (DM) intake and milk production (1.5kg/cow per day compared with cows grazing grass-only swards (Harris *et al.*, 1997; Ribeiro-Filho *et al.*, 2003). Therefore, there is renewed interest in the use of perennial ryegrass ploidy and white clover (*Trifolium repens* L.; hereafter referred to as clover) to increase

animal performance and pasture DM production. The sustainability of pasture-based production systems may also be improved by substituting inorganic nitrogen (N) fertilizer with symbiotic N fixation (Lüscher *et al.*, 2014).

## The experiment

The experiment was established in Clonakilty Agricultural College in 2012 and 2013. Seventy five percent of the experimental area was reseeded in 2012 and 25% reseeded in 2013. Four separate grazing treatments were sown on the experimental area: a tetraploid only sward (TO); a diploid only sward (DO); a tetraploid with clover sward (TC) and a diploid with clover sward (DC). Four diploid (Tyrella, Aberchoice, Glenveagh and Drumbo) and four tetraploid (Aston Energy, Kintyre, Twymax and Dunluce) cultivars were sown as monocultures, with and without clover, to create a separate farmlet of 20 paddocks for each treatment. In the clover paddocks, a 50:50 mix of Chieftain and Crusader white clover was sown at a rate of 5kg/ha. There were 30 cows in each treatment group and treatments were stocked at 2.75 cows/ha, each paddock received 250kg of N fertilizer per hectare and target concentrate supplementation was 300kg/cow for each treatment. As cows calved in 2014 and 2015, they were randomly assigned to their treatments



and they remained on those treatments for the remainder of the grazing season within each year. The four treatments (swards) were rotationally grazed from mid-February until mid-November each year. The objective of the experiment was to compare milk and pasture production from tetraploid and diploid swards sown with and without clover. The results presented are from 2014 and 2015.

### Pasture production results

Perennial ryegrass ploidy had an effect on DM content, post-grazing height and pasture allowance as the diploid treatments (DO and DC) had greater values than the tetraploid (TO and TC) treatments for DM content (18.5% vs. 17.6%), pre-grazing yield (1,789kg vs. 1,696kg DM/ha), post-grazing height (4.3cm vs. 4.1cm) and pasture allowance (17.1kg vs. 16.0kg DM/cow per day). Clover inclusion had a significant effect on sward DM content as the grass-clover swards (TC and DC) had a lower DM content than the grass-only swards (TO and DO; 16.7% vs. 19.3%). Clover also

had an effect on post-grazing sward height as the grass-only swards had a greater pre- and post-grazing height compared with grass-clover swards (9.1cm and 4.4cm compared with 8.8cm and 3.9cm, respectively). The effect of clover inclusion in the sward on daily pasture growth during the two years of the experiment is illustrated in Figure 1. Daily pasture growth rates were greater for grass-clover swards than grass-only swards from June to September by an average of 15kg/DM per day. As a result, on average, over the two years of the experiment to date, total pasture DM production was 1.9t DM/ha greater on the grass-clover swards (17.4t DM/ha) compared with the grass-only swards (15.5t DM/ha).

### Milk production results

The effect of treatment on milk production during the two years is presented in Table 1. Ploidy had no significant effect on any of

the milk production variables. Clover had a significant effect on all milk production variables with the exception of days in milk, fat and protein content. Both milk and milk solids yield per cow and per ha were greater for cows on grass-clover treatments compared with the grass-only treatments. Cows on grass-clover treatments produced 784kg more milk and 58kg more milk solids than cows on the grass-only treatments, which resulted in an extra 2,156kg and 168kg milk and milk solids yield per ha, respectively.

Table 1. The effect of treatment on milk production variables over two years (2014 & 2015).

	Treatment <sup>1</sup>				Significance <sup>2</sup>		P*C
	TO	DO	TC	DC	P	C	
Days in milk (days)	276	277	277	277			
Milk yield (kg/cow)	4,972	4,994	5,783	5,750		***	
Fat (g/kg)	46.9	46.4	46.2	46.1			
Protein (g/kg)	38.2	37.4	37.4	37.4			
Lactose (g/kg)	47.7	47.7	48.2	48.4		**	
Milk solids yield (kg/cow)	420	423	481	478		***	
Milk yield (kg/ha)	13,673	13,732	15,904	15,814		***	
Milk solids yield (kg/ha)	1,162	1,145	1,328	1,316		***	

<sup>1</sup>TO = tetraploid only; DO = diploid only; TC = tetraploid + clover; DC = diploid + clover.

<sup>2</sup>Significance; \*\*\* = P<0.001; \*\* = P<0.01; \* = P<0.05; P = ploidy; C = clover.

### Summary

Perennial ryegrass ploidy did not affect pasture DM or milk production over the first two years of this experiment. Incorporating clover into perennial ryegrass swards increased pasture DM production and milk production (per cow and per ha). The early results from the Clonakilty experiment are very promising, but potentially important issues with clover persistency, spring pasture DM production and bloat require further investigation.

### Acknowledgements

The authors would like to acknowledge funding from the Irish Farmers Dairy Levy Trust and the Teagasc Walsh Fellowship Programme. We would like to thank the technicians and farm staff at Clonakilty for their help throughout the experiment. We would also like to thank Luc Delaby, INRA, (the French National Institute for Agricultural Research) for his assistance with the analysis of the data.

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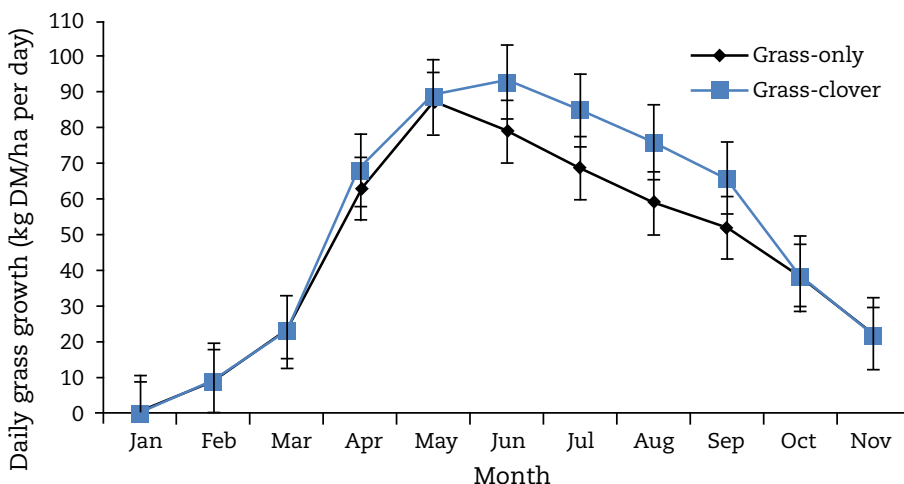
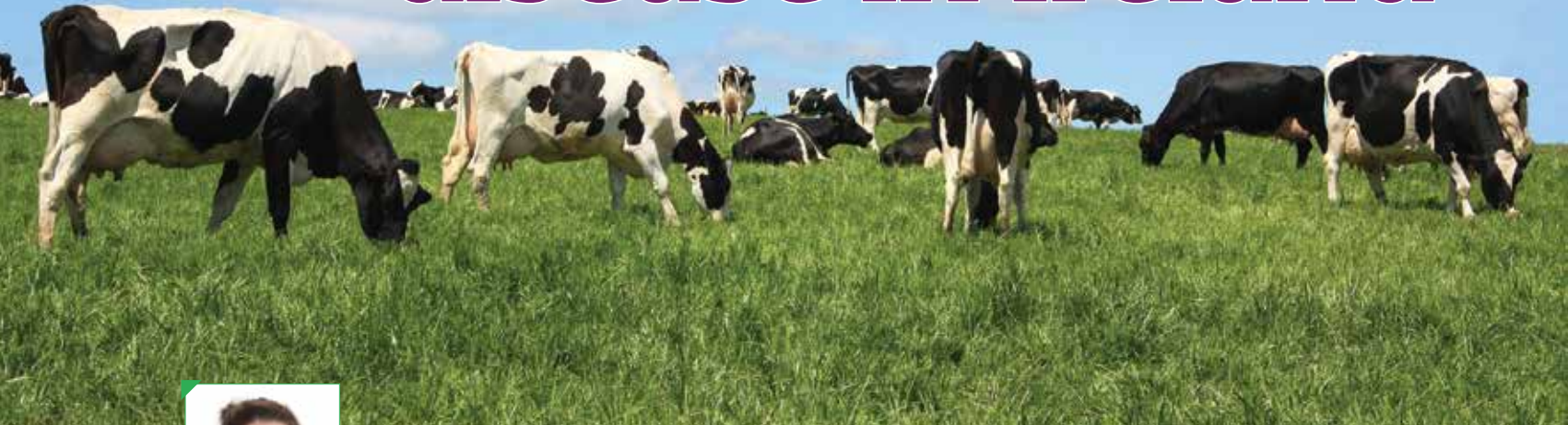


Figure 1: The effect of sward type (grass-only and grass-clover) on daily pasture growth rates for each month over two years (2014 and 2015).

# Control of Johne's disease in Ireland



This article reports on the first four years of a Johne's disease control programme on a Teagasc dairy research farm.



Johne's disease (JD), a chronic incurable diarrhoea, is caused by *Mycobacterium avium* subspecies *paratuberculosis* (MAP). Infection with MAP most commonly occurs in calves, but clinical signs usually do not become apparent until adulthood. Thickening of the intestines occurs as the disease progresses; preventing absorption of nutrients and leading to weight loss and diarrhoea (Ayele *et al.*, 2001).



## Impact of Johne's disease

Infection with MAP has been associated with economic losses in dairy enterprises, primarily due to reduced milk production and sub-optimal fertility (Hasonova and Pavlik, 2006). As a result of economic concerns, the impact on animal welfare, and the hypothesised zoonotic link between JD in cows and Crohn's disease in humans, many international JD control programmes have been established. The majority of these programmes aim to break the cycle of JD transmission via identification and removal of infected animals and hygienic dry-cow and calf management.

## Control programme for Johne's disease

Due to the slow and progressive nature of the disease, identification of infected/infectious

individuals is problematic. Diagnostic tests that are available include faecal culture, polymerase chain reaction (PCR) and enzyme-linked immunosorbent assay (ELISA). Currently, there is no test available with perfect sensitivity and specificity for JD diagnosis in subclinical animals. However, due to its speed and relatively low cost, ELISA testing remains a popular diagnostic choice for control programmes (including Animal Health Ireland's pilot national JD control programme).

In order to further examine the usefulness of ELISA testing in an Irish context, a research team at Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, has established a control programme on a dairy research farm, which utilises serial ELISA testing as the basis for initial identification of positive animals. Dry-cow management, calf management and culling of high-risk cows also forms part of the control programme.

Before commencement of the programme, no clinical cases of JD had been reported in the herd. A sampling protocol was initiated in May 2012 involving monthly collection of blood samples for ELISA testing. This monthly protocol continued until December 2014, at which point sampling continued on a quarterly basis. All samples were tested using the ID Vet kit (Montpellier, France). Faecal samples from ELISA-positive cows were collected and tested by PCR and faecal culture on an intermittent basis during the study. ELISA-positive cows were subject to veterinary examinations throughout the testing period.

In 2013, a single cow (Cow A) was selected for pathological examination (PE) on the basis of repeatedly recording high positive ELISA readings.

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Post mortem images of thickened and corrugated sections of intestine from an animal infected with Johne's disease.

Cow A also yielded positive PCR results and a single faecal culture positive result. In winter 2013 and winter 2015, a number of additional cows that were due to be culled, as per normal farm practice, were selected for PE. Given the variable nature of MAP diagnostics, only cows with consistent ELISA-positive test results for JD were considered for PE.

In terms of herd management, all cows that recorded at least one ELISA-positive result were calved in isolation and returned to the herd post-calving. Colostrum from these cows was discarded, and their calves were fed colostrum from a dam that consistently had ELISA negative test results for JD. All other calves only received colostrum from their own dam.

## Results

At the first sampling in May 2012, 10 of the 139 cows had ELISA-positive test results for JD. The highest number of ELISA-positive test results for JD recorded over the testing period was in July 2013, when 16 cows were categorised as positive. It should be noted that this excludes the three month period likely to be influenced by statutory annual testing for bovine tuberculosis. Veterinary examination did not yield any clinical signs of JD in these animals.

Pathological examination of Cow A revealed severe gross changes consistent with JD (July 2013). The remaining cows sent for PE (selected based on consistent ELISA-positive readings only), showed no lesions indicative of the presence of MAP. Following culling in winter 2013, nine cows that had intermittently recorded ELISA-positive test results for JD remained in the herd. Within three months of the final cull, these cows recorded negative ELISA results. The entire herd remained ELISA negative until summer 2015 at which point five cows were categorised as ELISA-positive. Of these, a single cow (Cow B) recorded a very high ELISA reading. As this cow was due for routine culling, and had previously tested ELISA-positive in January 2014, she was subjected to PE in November 2015. No gross lesions were identified on PE. Histopathology results from this cow are pending.



Normal intestine from an animal showing no signs of Johne's disease.

Animals reared using JD management protocols are due to enter the milking herd in spring 2016, which will allow the research team to further study the impact of the control programme on this herd.

## Implications of ELISA results for control programmes

Use of serial ELISA sampling identified a cow clinically positive for JD, which could have acted as a source of MAP within the herd. Taken as a whole, however, the results of this programme indicate that consistently positive MAP ELISA results are not a definitive indicator of the gross pathological lesions associated with JD. Additional tests (faecal culture or PCR), therefore, should be used to more definitively identify cows for culling. Culling programmes combined with appropriate calf management have the potential to reduce the herd prevalence of MAP ELISA-positive results. It is likely, however, particularly in an Irish context, that cows may be culled unnecessarily if ELISA readings are used as the only indicator of disease. Finally, this study highlights the long-term nature of JD-control programmes. This should be highlighted to all farmers and veterinarians planning JD-control programmes in order to prevent unrealistic expectations and subsequent distrust of such schemes.

## Acknowledgements

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CELU

# High-precision field trials

Sowing beet trials: The autosteer system allows precise machine placement without previous marking or driver steering input.



**Dermot Forristal and Brendan Burke were key personnel in the delivery of a GPS-based positioning solution to make crop research trials more efficient.**



Field trials are the cornerstone of crop research. While some new developments may have their genesis in a lab, virtually all must be trialled in the field. Field trials are labour intensive and time critical. More precise global navigation satellite systems (GNSS), commonly described using the term ‘global positioning system’ (GPS), have the scope to radically change how we do this trial work. At Oak Park we have recently changed completely to a GPS-based, precision-trials sowing system. The technology used is identical to that available to farmers today; although it is deployed in a different way and the most precise positioning signal (RTK) is used. It has allowed a complete section of the trialling process to be automated, facilitating a significant improvement in efficiency.

The Teagasc Oak Park crops field trial programme covers all aspects of crops research including: genetic development/varieties; crop establishment; crop development/physiology; nutrition; and disease, pest and weed control. The range of crops trialled includes: cereals; oilseeds; protein crops; bioenergy crops; beet; and potatoes. In excess of 10,000 plots are planted, monitored and harvested annually.

## Plot sizes and trial sizes

The trial plot is the base experimental unit where new research is evaluated. Plot size is determined usually by the plot harvester to be used, with cereal plots varying from 1.5m to 2.75m in width and 6m to 24m in length. The number of plots in any one trial is determined by the number of factors (or treatments) that are being examined and the number of times the individual plots are replicated across the trial site to account for variability in the soil and in the experimental procedure. A typical trial may have from 40 to 400 plots. Each plot must be individually established, managed and measured and, as each of these operations is time critical, any time- or labour-saving options must be pursued.

## Speeding up the operation

While speed and efficiency are important in plot management, accuracy and precision are critical. At Oak Park, trial procedures have been changed to improve efficiency. One-pass plot cultivation and sowing has been adopted saving a tractor and man and increasing the output of the research team. Fully instrumented combines with complex electronic weighing systems and data collection have replaced slower manual-weigh system machines.

The next but larger step to be considered was to adopt satellite-based positioning technology to greatly

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improve field trial efficiency by eliminating the need to accurately mark out field trials manually, in advance of sowing. Oak Park has adopted this technology over the last two cropping seasons.

### Precision agriculture technology

Precision agriculture (PA) technology, which is largely based on satellite positioning such as GPS, has been in existence for more than 20 years. While development of some aspects of PA has been slow, positioning technologies and position-related machine control has developed rapidly, allowing it to be considered for field trial use. Key developments have been in:

**Positioning accuracy:** accuracy is essential for plot work. The highest accuracy agricultural RTK GPS offers a positioning signal that is within 2cm of the real position. This is essential for research trial use. Lower levels of accuracy (4-8cm and 15-20cm systems) are more commonly used on farms.

**Auto-steering control:** tractor or machine steering is automatically controlled to precisely guide the tractor and implement more accurately than an operator could achieve. This allows perfectly parallel and equidistant plots to be sown and steering lines to be set out at 90° angles to a base line.

**Tractor display and controller:** controller display units control the machine guidance functions (including auto-steering) and can control any implements attached to the tractor.

### Setting out trials the old way

For most trials, accurate surveying/marketing in advance of sowing the individual plots, using two to three people with tapes, measuring wheels and ranging poles, was essential. For many trials it could take the same length of time to mark it out as to sow it (e.g., three hours for each). Where plots could not be sown side by side simultaneously (such as trials with different sowing dates or using different cultivation tools) the set-out time could take even longer. With weather restricting sowing opportunities and limited personnel and equipment resources, the attraction of reducing/eliminating this marking out time was clear.



The display unit in the cab shows the operator where the plot lines are but steering and seeder control are completely automatic, eliminating the need for time-consuming marking out and accurate operator steering.

### Changing to a GPS-controlled system

As the potential time and efficiency gains were clear, a decision was made to adopt a GPS-based system. As the level of deployment being planned had not been implemented by any other research centre in Europe to our knowledge, the specification was carefully chosen and included:

- full-RTK level GPS, giving 2cm positioning accuracy;
- virtual positioning correction, allowing us to set up instantly anywhere in the country without the need to install a local base station;
- autosteer with direct control of tractor's steering valve; and
- in-cab screen/controller that would allow seeder control with an electronic actuator.

Five complete RTK control units were purchased, which can be fitted to any of six tractors with full autosteer control. These are based on Trimble FMX 1000 display/control units and VRS RTK correction signal.

### Using the system

Using the system is simple. When the tractor/seeder is driven into a field, a baseline is simply chosen by driving between two points in the field. The operator sets the plot width, the plot length and orientation of the plots to the baseline (normally 90°). Visible plot lines appear on the screen and the driver lines up approximately with the first line, selects autosteer and leaves the steering wheel free. The GPS-controlled autosteer system then steers precisely along the plot and trips the seeding mechanism at every plot end. At the end of a run, the operator turns the tractor around and then sets the controller to steer again, sowing perfectly parallel at the correct distance to the previous run.

The system has worked effectively from the start of deployment with researchers, technicians and operators very quickly getting to grips with the technology and optimising its use for their particular purpose. The key benefits have been:

**Plot seeding:** set-up time has been practically eliminated, frequently resulting in a doubling of daily plot-sowing output with a two-person team. Good plot layout in the field is easily achieved. This has been achieved with cereals, oilseeds, beans, potatoes, grass and beet.

**Tramline placement:** the system allows precisely positioned cross-plot tramlines to be placed, accurately setting plot length for harvest.

**Trials in commercial fields:** the equipment allows 24m spreading and spraying equipment to be controlled within a commercial field to create a trial lattice.

**All trials:** permanent field-trial baselines can be created and stored electronically to ensure the exact location of trials is recorded for future use.

Overall, while the technology is expensive (€20,000/tractor unit), it has been cost effective, allowing a huge trials programme to be implemented with limited staff and machine resources. While with trial plots we have more to gain than commercial farms, this technology will become commonly used on farms as its price falls.

### Acknowledgements

The adoption of GPS-based trials equipment was funded by Teagasc core funding.

# High Nature Value farmland

Cattle grazing on semi-natural grasslands in Mullaghmore, Co Sligo.



Nationally and internationally, food processors and retailers place high importance on the environmental sustainability of Irish food production. In support of this objective, the IDEAL-HNV (Identification of the Distribution and Extent of Agricultural Land of High Nature Value) project has been investigating the distribution and characteristics of High Nature Value farmland in Ireland that contains high levels of biodiversity.



## What is HNV farmland and why is it important?

High Nature Value (HNV) farmland has been defined as “those areas in Europe where agriculture is a major (usually the dominant) land use and where agriculture sustains or is associated with either a high species and habitat diversity, or the presence of species of European conservation concern, or both”. Maintaining both the nature value of this farmland and the livelihoods of farmers in these areas is a key policy challenge in the years ahead.

The importance of HNV farming systems is now well recognised across a number of policies, not just for their biodiversity, but also for their provision of environmental public goods including clean air, clean water, stable climate, aesthetic landscapes and vibrant rural communities. Conservation of natural resources (including biodiversity) and halting the degradation of ecosystem services are key environmental objectives of the European Union. The European Commission includes HNV farming and forestry systems as one of the seven headline indicators of environmental impact. Member States are required to identify areas with HNV farming practices, to support and maintain HNV farming through Rural Development Programmes, and monitor changes to HNV farmland area over time.



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## The IDEAL-HNV project

Due to the absence of national habitat maps, there is very limited knowledge of the spatial distribution of HNV farming systems that occur outside of designated sites in most Member States, including Ireland. Many Member States require a major effort to fill the data gaps on the distribution and character of HNV areas. With this in mind, the IDEAL-HNV project was initiated in 2012, and had the following key objectives:

- develop and apply GIS methods for identifying HNV farming systems;
- develop a typology of HNV farming systems in Ireland;
- examine the use of remote sensing methods to identify HNV areas at the farm scale;
- develop bottom-up decision-support tools to assist field- and farm-scale identification of HNV farmland; and
- Analyse the socioeconomic status of HNV farming systems.

## Predicting the distribution of HNV farmland in Ireland

Here, we focus on one of the objectives, the development of geographical information system (GIS) methods to improve prediction of the likely distribution of HNV farmland. We mapped the likely distribution of HNV farmland based on established European indicators adapted for Ireland using the following indicators:

- semi-natural land cover classes from Corine 2012;
- stocking density from the Department of Agriculture, Food and the Marine;
- percentage hedgerow cover from Teagasc's National Hedgerow cover map;
- length of river and stream from Ordnance Survey Ireland river-stream map; and
- soil diversity calculated using the Teagasc map of soil associations.



Data were modelled at the tetrad scale (2km x 2km), and presented here at the scale of Electoral Divisions. The resulting map (from Matin et al., in review) indicates the likely occurrence and distribution of HNV farmland in each Electoral Division, based on a scale ranging from very low (blue colour) to intermediate (yellow) to very high (green) (Figure 1). Not surprisingly, western counties such as Kerry, Clare, Mayo, Galway, Leitrim, Donegal and Cavan exhibited greatest likelihood of containing HNV farmland while Dublin, Meath and Kilkenny had lowest likelihood. Nevertheless, there is considerable variation within counties.

To our knowledge, this is the first Irish national-scale map that has used objective agri-environmental criteria to predict the likely distribution of HNV farmland. This provides a reference point for the future monitoring of the distribution of HNV farmland in Ireland. It can also assist in policy planning and development for the rural environment. For example, comparisons of the spatial distribution of HNV areas and the spatial distribution of agri-environmental and other payments can assess the degree to which payments are targeted toward HNV farming systems. In addition, these data can be used to incorporate impacts on farmland biodiversity of, for example, land-use change and climate change in national-scale models or scenarios.

As an indicator-based prediction, such maps should be interpreted within the limitations of the data used. The spatial scale of the map is restricted by the coarse scale of data at national level. Given the predictive and aggregated nature of the outputs, it is important to note that non-HNV farmland may still occur in areas with high likelihood of HNV farmland, and vice versa. We also know that some very specific types of HNV farmland are not well-represented by this approach. For this reason, this output is not suitable for strictly deciding whether farmers in certain areas should be eligible or not for agri-environmental measures aimed at HNV farming systems. Instead, there is a requirement for a farm-scale assessment to confirm the HNV of individual farms. As part of the IDEAL-HNV project, we also examine the farm-scale characteristics of HNV farmland. See the project website ([www.high-nature-value-farmland.ie](http://www.high-nature-value-farmland.ie)) for further details.

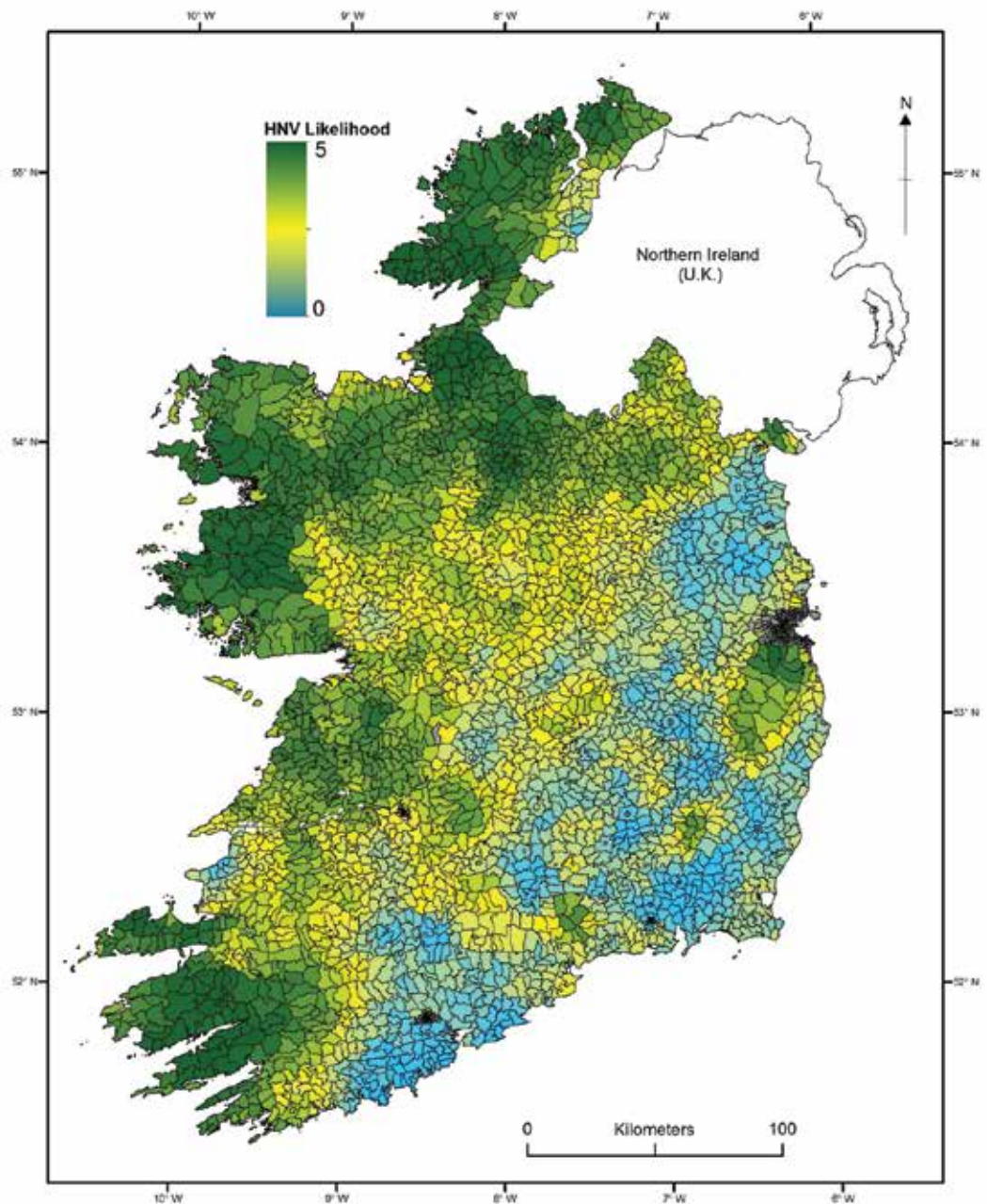


Figure 1. Likely occurrence and distribution of HNV farmland in each Electoral Division, based on a scale ranging from low (blue) to intermediate (yellow) to high (green). Note that non-HNV farmland may still occur in areas with high likelihood of HNV farmland, and vice versa.

### Acknowledgements

Daire Ó hUallacháin, David Meredith, James Moran and Stuart Green also contributed and are members of the IDEAL-HNV project. This research was funded by the Stimulus Research Fund (award 11/S/108) of the Department of Agriculture, Food and the Marine through the National Development Plan 2007-2013.

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# Potential availability of land for forestry

A new study by Niall Farrelly and Gerhardt Gallagher shows that, in principle, there is sufficient land available to facilitate the acceleration of afforestation that could be used to increase production and for offsetting agricultural greenhouse gas (GHG) emissions.

Forestry expansion has re-emerged at the top of the land-use agenda in Ireland, driven by the need to produce enough fibre to create a sustainable processing sector and the potential for forestry to sequester carbon and offer mitigation potential for agriculture and related sectors. To provide for increased carbon sequestration, an urgent, accelerating new-forest planting above current levels (as well as correcting an unbalanced age-profile within the forest estate), is necessary. The question arises – do we have sufficient land resources to facilitate forestry expansion? A new study, undertaken by Teagasc, has succeeded in identifying the potential availability for land forestry (Farrelly and Gallagher, 2015). The results of this study suggest that an efficient use of land resources could provide a significant land base for the sustainable expansion of the carbon resource and achieve forestry targets that would not impact on food production targets and conservation objectives.



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## Classification of land use in Ireland

An assessment of land use in Ireland was performed in a geographic information system (GIS) using a series of the most up-to-date spatial datasets available on land-related activities, soils and potential agricultural land use (Figure 1). The GIS-analysis method combines features from multiple datasets and uses this information as the basis to classify land into the five categories based on opportunities and constraints for afforestation as follows:

### Land biophysically unavailable for forestry

An area of 1.49 million ha, 21.3% of the land area of Ireland, was classified as being biophysically unavailable for afforestation (classified as forest, urban, water, road and rail, electricity utilities and buildings).

### Land biologically unsuitable for forestry

An additional 850,238ha, 12.2% of the land area was considered to be biologically unsuitable for

afforestation, being composed of intact raised bogs, fens, sand dunes, coastal complexes, salt marshes, rock outcrops and karst areas or unproductive for commercial afforestation.

### Land subject to national and EU designations and policies

A further 897,121ha, or 12.8%, of land was affected by national and EU designations and policies and, therefore, has limited potential for afforestation.

### Productive agricultural land

Of the remaining land, 2.45 million ha of land is classified as productive agricultural land being suitable for a wide range of agricultural enterprises with no real limitations (Gardiner and Radford, 1980) (Figure 1). Almost all of this area is suitable for grassland and tillage (2.3 million ha). There are also smaller areas of wet grassland and unimproved lands, a total of 112,000ha that is not separated out due to the limitations of scale used in the analysis that may be more suitable for afforestation (Table 1). Farming enterprises are cattle – non-dairy (42%), dairy (25%), tillage (12%), sheep (12%) and mixed livestock (5%), with average farm income calculated at €30,761 per annum per household in 2013, according to Teagasc National Farm Survey (Moran, 2014).

Table 1. Area of land potentially suitable for afforestation, according to productive and marginal agricultural land (Gardiner and Radford, 1980) and the area that is likely to have the most potential.

Land cover	Productive agricultural land (ha)	Marginal agricultural land (ha)	Total area (ha)
Tillage and grassland	2,217,782		2,217,782
Reclaimed grassland	118,299	186,500	304,799
Dry/improved grassland		804,836	804,836
<b>Land with most potential</b>			
Wet grassland	87,785	156,219	244,004
Other unimproved lands	24,647	154,349	178,996
<b>Total area</b>	<b>2,448,513</b>	<b>1,301,904</b>	<b>3,750,417</b>

### Marginal agricultural land

An area of 1.3 million ha of land is classified as being marginal agricultural land; being composed of more difficult soils requiring more intensive management to maintain, in production. A large proportion of the land is classified as improved and reclaimed grassland (991,000ha). There are larger areas of wet grassland

and unimproved lands here (310,000ha) that have potential for afforestation. In these areas, farming enterprises were predominately cattle (49%) and sheep (27%) systems, with lower levels of dairy (18%), mixed livestock (4%) and tillage (2%). Overall, the profitability of farming enterprises on marginal land was lower than on productive agricultural land with average farm income of €17,006 per annum per household.

**Opportunities for forestry expansion**

As the quality of land is often a determining factor in the land-use decision-making process, lower quality land that presents difficulties for economic agriculture, may present a viable economic enterprise for forestry. Therefore, there are 423,000ha of land (wet grassland and unimproved land) that occur on the margins of productive agricultural land and in marginal agricultural areas that have significant potential for afforestation. The addition of these lands in the planting programme would represent an area approaching 17% in forest cover in Ireland, and a land-use strategy to facilitate the achievement of planting targets. It is likely that this increased afforestation will satisfy key demands from our land; increasing the production of raw material for the processing sector and providing considerable scope for increased forest sequestration to mitigate GHG emissions. This study shows that, in principle, there is sufficient land available for acceleration of afforestation from current rates (c. 6,300ha per annum) to 16,000ha. The utilisation of marginal and unimproved land may represent a very efficient use of natural resources in which to expand the carbon resource that could be used for offsetting agricultural and national GHG emissions.

**Acknowledgements**

This research was funded by Forest Sector Development, the Department of Agriculture, Food and the Marine and commissioned by the COFORD land-availability working group and their support is gratefully acknowledged.

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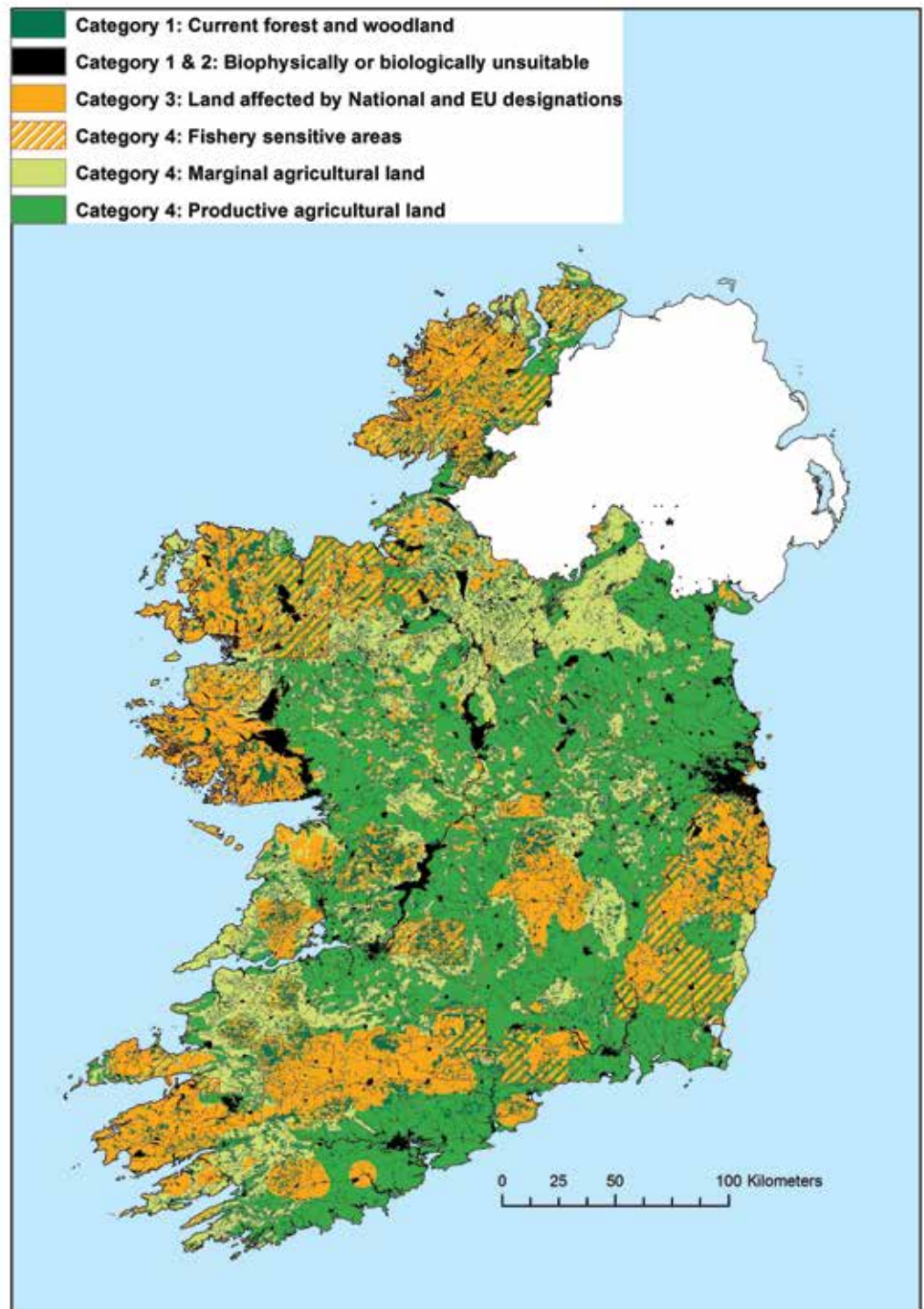


Figure 1. Classification of Ireland's land area in relation to availability for forestry expansion and the area of productive and marginal agricultural land with most potential for forestry expansion.



# Specialised nutritional powders driving commodity valorisation



Teagasc Food Research Centre, Moorepark, provides state-of-the-art pilot and analytical capabilities for the production of specialised nutritional products.

The abolition of milk quota in Ireland has led to an increase in milk supply of over 11% – equivalent to an additional 600 million litres of milk – during the first 10 months of 2015. However, increasing production has been coupled with market volatility in 2015. China, in particular, has seen a significant slowdown in dairy imports, with whole milk powder and skim milk powder import volumes reducing by 50% and 20%, respectively, compared to 2014 figures. Conversely, Chinese imports of specialised nutritional dairy powders were 38% higher, with Ireland now positioned as the second largest

import supplier. Specialised nutritional powders can include infant formula, fat-filled powders and specialised powders targeted for sports nutrition, medical, and life-staged nutrition. In general, specialised nutritional dairy powders, which now account for 35% of total Irish dairy powder exports, were valued at about €1.5 billion in 2015 (Bord Bia, 2015-2016, Export Performance & Prospects, Irish Food, Drink & Horticulture). These figures highlight market opportunities to create higher volumes of specialised nutritional powders, as opposed to typical commodity powders, particularly at times before and after the peak milk supply, so as to maximise dryer usage. Production strategies incorporating value-added specialised nutritional powders, as part of the product portfolio mix, may help insulate the Irish dairy industry against continued market volatility.

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### Pilot plant and analytical capabilities at Moorepark

Stabilisation and storage of additional milk volumes continues to be driven by dehydration technologies, predominantly spray drying, and it is likely that any increases in the production of specialised nutritional powders will be produced on existing spray-drying platforms currently utilised in the production of dairy commodities. A shift towards specialised nutritional powders would necessitate a consideration of the diversity and complexity of the concentrate (pre-drying), whereby the impact of composition (protein carbohydrate, lipid, mineral composition and dry matter) and process technologies (heating, homogenisation, evaporation and spray drying) affects subsequent powder quality. Powder quality and functionality is judged predominantly by its behaviour in the dry state and also during and post-rehydration; they are also governed by specific powder characteristics including density, interstitial and occluded air, particle size, solubility, dispersibility, wettability, floodability and hygroscopicity. Competency in both pilot plant and analytical capabilities that have been developed at Teagasc Food Research Centre, Moorepark, create a platform for the production and characterisation of a wide range of commodity and specialised nutritional powders, and provide a key component in developing new functional dairy powders to utilise the expanding milk volume in Ireland.

### Physical properties and challenges

Specialised nutritional or fat-filled dairy powders are often considered to be an economical replacer of full-cream milk powder and have a global market reach.

Apart from their use in specialised nutritional product applications, fat-filled powders also find application in the main markets for dairy commodities including: ice cream, bakery, confectionery, chocolate, biscuits, bread, cookies, processed cheeses, sweetened condensed milk, soups and sauces.

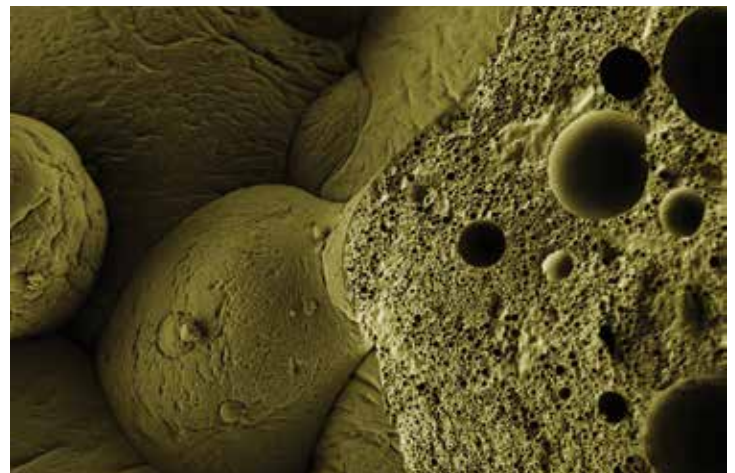
Typically, vegetable oils are used as milk-fat replacers and are added to liquid skim milk to standardise the fat and protein content dependent on the end application. Specific regulations vary on minimum protein and fat content dependent upon market destination. Fat-filled milk powders are defined under Codex Alimentarius regulations (World Health Organization) as a product comprised of milk components that have been substituted partially by non-milk components. Food additives may be permitted to improve the product's appearance, characteristics and composition. Commercial, high-end powders intended for life-staged nutrition (e.g., infant milk formula, follow-on formula, sports nutrition and medical nutrition), may also be considered under the global umbrella of fat-filled milk powders. The types and blends of vegetable oils (e.g., sunflower, palm, coconut, soy) used in first-stage infant milk formulas (i.e., for infants up to six months) are carefully selected to simulate the fatty acid profile of human milk. These oils are blended with skim milk, whey protein concentrates or milk protein concentrates in varying proportions according to the desired protein profile.

### Process technology

Ongoing research at Teagasc Moorepark is examining the impacts of process technology on the properties and functionality of fat-filled milk powders. Areas being investigated include evaluation of the effects of homogenisation (pressures, number of stages, temperature), thermal processing (time temperature conditions, flow conditions), evaporation (single and multiple effects, batch and continuous production scenarios) and spray-drying conditions (single and multi-stage drying, rotary wheel, low and high pressure nozzle atomisation, and thermal transitions within the drying process) on the final stability and shelf-life of fat-filled powders. It is often the case that both mineral composition and protein profile of fat-filled milk determines specific manufacturing conditions, necessitating process design which limit the impact of protein aggregation and plant fouling on process efficiency. Current research themes include mapping best ability of milk concentrates to understand the impact of physical characteristics (e.g., viscosity, particle size) on the performance of fat-filled powders during and after the drying process. Selection of appropriate, product-specific, atomisation technologies is critical in modulating the properties of the final fat-filled powder, including particle size, morphology (shape), solubility, wettability and hydration properties.

### Free fat levels in powders

An increase in the level of free fat in fat-filled powders can create conditions favourable to fat oxidation and the formation of off-flavours, in addition to negatively effecting powder functionality; for example, leading to poor re-wetting characteristics (flowability, dispersibility, wettability). Unfortunately, the presence of free fat cannot be totally avoided; however, it can be reduced by ensuring adequate homogenisation efficiency, coupled with careful evaluation of unnecessary pumping and agitation scenarios, such as recirculation in the evaporator. Current work on free-fat issues in low-protein, fat-filled milk powders is yielding interesting findings that could help minimise free-fat levels in future dairy powders. Conversely, free fat is desirable in fat-filled milk powders for use in the manufacture of chocolate, in which, free fat facilitates the interaction of the powder with the cocoa butter.



Scanning Electron Micrograph of a milk powder. Image courtesy of the National Food Imaging Centre, Teagasc Moorepark.



# Fat and salt in processed meat products

## - a challenge for industry

The PROSSLOW project is developing healthier traditional processed meats through the reduction and/or replacement of salt and fat.

Processed meat products are widely consumed in Ireland, and also represent an important part of the meat sector sales and exports from Ireland. The total value of Irish beef and pigmeat exports reached €2.27 billion and €570 million in 2014, respectively (Bord Bia, 2015). Their importance for the meat industry is beyond doubt; however, from a consumer health point of view, meat products have always been in the spotlight. High consumption of meat and processed meat products has been regularly linked to increasing risk of chronic diseases like cardiovascular disease, obesity, diabetes and certain types of cancer – the World Health Organization (WHO) recently included processed meat in the carcinogenic list. Much of the focus has been on fat and sodium levels, which are traditionally high in processed meat.

### Excess of fat and salt

High fat levels increase the caloric content of the product and consumption of high-fat products can enlarge the gap between energy intake and expenditure. Even a relatively small energy imbalance over time could generate substantial weight gain and eventually lead to obesity. According to the National Adult Nutrition Survey (IUNA, 2011), meat and meat products are the greatest contributors to fat and energy intake in Irish people.

High sodium consumption increases systolic blood pressure and leads to hypertension; 20% of Irish men and 7% of women aged 18 to 64 years suffer from this condition (IUNA, 2011). Salt provides about 90% of the sodium in the human diet. The WHO recommends an intake of less than 5g of salt per day for adults. Yet, the mean daily intake for Irish adults (aged 18 to 64 years) was 7.4g of salt in 2011. Processed food consumption accounts for more than two thirds of sodium intake in Ireland, with processed meats being one of the main contributors to this (IUNA, 2011).

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### A technological challenge

Fat and salt are important constituents of traditional processed meats, playing key technological and sensory roles. Fat content has an important effect on flavour, texture, bite, and mouthfeel. Salt also affects the sensory characteristics of the products, but it has an important additional role in their preservation. Therefore, low-fat and/or low-salt meat products present compound challenges on the manufacturing side.

Traditional processed meats are an important part of Irish culinary culture and, due to their high consumption, represent a significant source of nutrients in our diets. Meat and meat products are the greatest contributors to protein (of high quality) and vitamin D intake in the Irish diet, secondary contributors to iron intake, and a good source of vitamin B and zinc (IUNA, 2011). The challenge facing meat scientists now is to provide the industry with the necessary knowledge to guide future manufacturing of healthier traditional meat products that can be consumed in moderation as part of a healthy diet and lifestyle. To accomplish our goal, we must rely on all the technological advances and scientific evidence at our disposal. Researchers in the PROSSLOW project aim to reduce fat and salt content, and minimise the use of additives in traditional processed meats, while maintaining the nutritional and sensory properties of the selected meat products. Research is being performed in the Teagasc Food Research Centre Ashtown and University College of Cork (UCC) under guidance from regulatory authorities, the industry and stakeholders.

### Fat and salt in Irish meats

Before reducing fat and salt content, it is paramount to establish the benchmark levels for these products, not only according to the regulatory authorities' guidelines, but also to determine the current mean industry levels. We purchased different traditional Irish meat products from retailers and recorded the fat and salt content according to their label (Table 1). Declared fat content differed depending on the

type of product, with streaky rashers having the highest. In products like white and black pudding (where fat is added as an ingredient) there was considerable variation in the declared fat content among different brands. In contrast, labelled salt levels for all products did not vary as much as declared fat.

We also analysed the composition of 30 different cooked hams and 36 bacon products purchased in four different Irish retailers. The salt content of the bacon products ranged from 1.24% to 4.71% with an average content of 2.53%. This mean value is below the Food Safety Authority of Ireland (FSAI)/industry-agreed guidelines for this type of product (3.3%) and also below the FSA (UK) salt objectives for 2017 (2.88%); however, 25% and 17% of the analysed samples still had values above these guideline levels, respectively. These results contrasted with the nutrition label, upon which all the products declared salt content equal to or below the FSAI guidelines. In the case of the ham products, the mean salt content of cooked hams was 1.74% (range 0.99-4.26%), while half of the samples contained salt levels above the guidelines (1.63%). According to the declared content, only four samples out of 30 had salt contents equal to or below the recommended levels.

Different types of cooked ham and bacon had different fat contents; streaky rashers and reformed ham had the highest fat content in bacon and cooked ham products, respectively.

Table 1. Declared content of fat and salt for different commercial Irish meat products.

	n	Fat (g/100 g)			Salt (g/100 g)			Guide*
		Average	Min	Max	Average	Min	Max	
Back rashers	17	15.31	8.5	22.5	2.75	2.3	3.1	3.3
Streaky rashers	6	20.27	14.2	25.1	2.72	2.4	3.3	3.3
Bacon joint	10	12.11	3.5	23	2.27	1.1	2.8	3.3
Ham fillet	6	7.75	5.3	12	2.9	2.5	3.3	1.6
Cooked ham	30	2.84	1.6	6.9	1.98	1.1	2.5	1.6
Black pudding	10	14	7.1	22	1.9	1.3	2.5	1.5
White pudding	10	12.6	6	17.5	2	1.5	2.5	1.5
Corned beef	7	11.14	8.5	13	2.16	1.67	2.5	1.5

\*FSAI guidelines

### Consumer acceptability

Optimisation through sensory analysis is a key aspect of the approach in this project. Small changes in salt and fat content may affect the sensory properties of the meat products. The UCC team developed a methodology, including consumer assessment, to investigate the links between the quality and sensory parameters of the product. This methodology, tested in several commercial products, provides a reliable, repeatable, fast and relatively inexpensive sensory analysis. Initial trials used commercial white and black pudding, which led to the development of a sensory questionnaire for subsequent use. This questionnaire separates the liking perception of the product (e.g., overall acceptability) from the sensory description (e.g., tough, salty, etc.). The team also applied the methodology to nine different corned beef products from Irish retailers. Panellists showed a clear preference for two of the brands – these samples shared similar characteristics such as a ham flavour and a low perception of fatty flavour. A similar approach will be applied across other traditional processed meats in both UCC and Teagasc.

### Strategies for salt and fat reduction

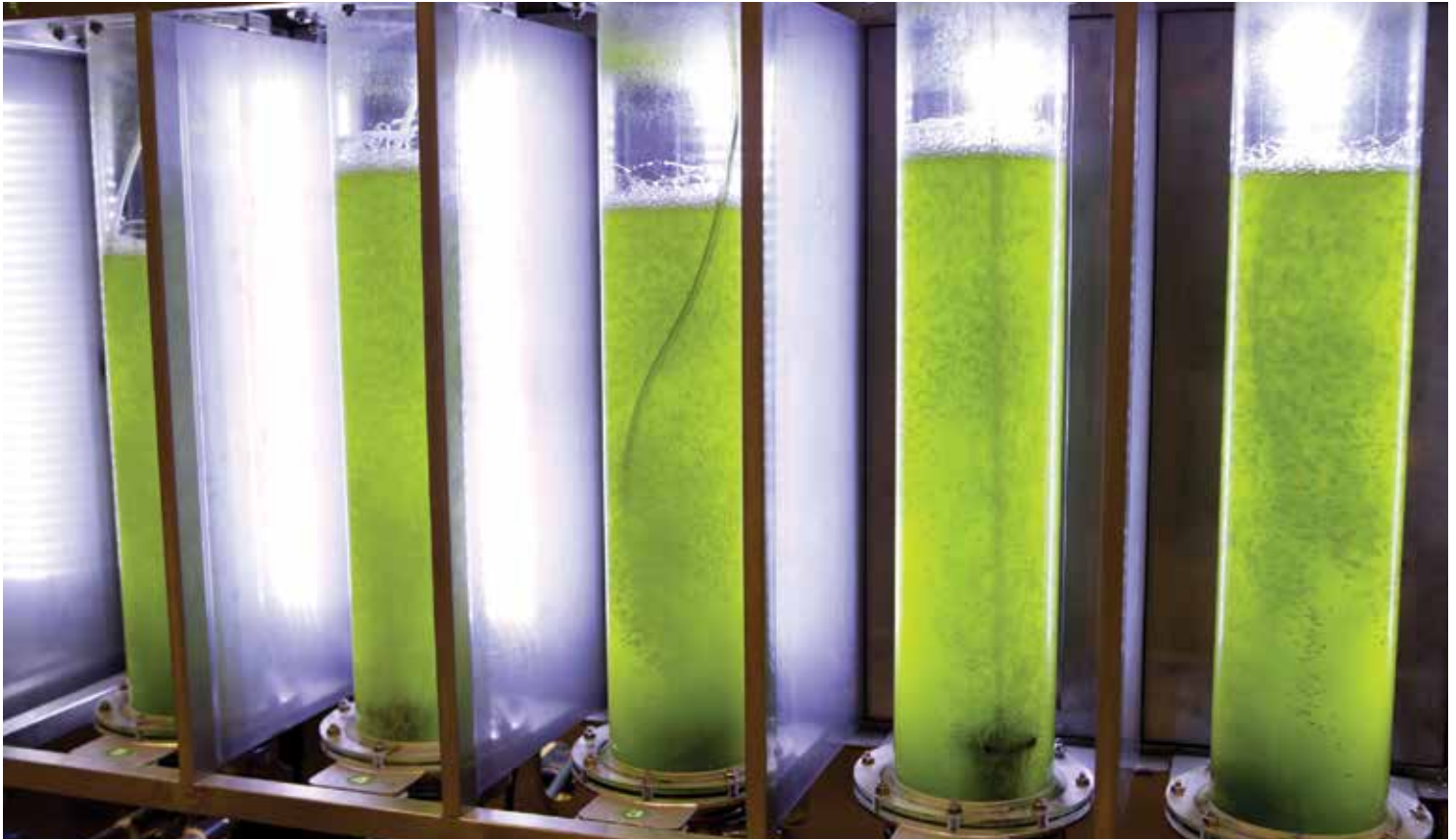
Based on the results so far, we have been able to establish benchmark levels for salt and fat content in each type of product. The observation that some retail products had salt levels below the guidelines suggests that the task can be accomplished. The strategy to follow varies depending on the product and composition. We will use innovative salt and fat replacers to obtain healthier traditional processed meat products in a cleaner label fashion, and place particular emphasis on consumer sensory quality, food safety and commercial viability.

### Acknowledgements

We would like to acknowledge Paul Allen (Teagasc Food Research Centre, Ashtown) for his contribution on this research. The UCC research component of this article was completed as part of the PhD project of Susann Fellendorf (School of Food & Nutritional Sciences, University College Cork) entitled 'Development of consumer accepted low salt and low fat Irish traditional processed meats'. The PROSSLOW project (11/F/026) is funded by the Department of Agriculture, Food and the Marine under the FIRM/RSF/CoFoRD programme.

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# EUALGAE: Microalgae proteins and ingredients



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Recently, Teagasc was the principal organiser of an EU COST action meeting concerning the use of microalgae for the development of higher value bio-products for feed, food, nutraceutical and cosmetic uses. Maria Hayes, who is the Irish management committee member for this COST network and the work group leader of work package three, which deals with refining of microalgae into value components, organised the first meeting in Dublin.

## Microalgae as a renewable resource

Biomass, as a renewable resource, is attracting worldwide attention to satisfy demand for food, feed and fuel in the so-called 'bioeconomy'. Conventional biomass feedstocks remain controversial due to limited land availability and competition with food and feed production. The ever-growing population will require more food and protein by 2050. It is predicted that alternatives to meat and fish could potentially make up 33%, or one third, of the world's protein market by 2054 (van der Spiegel, 2013). The mass production of certain protein-rich microalgae is considered as a possibility to close the predicted so-called "protein gap" (Becker, 2007). Comprehensive analyses and nutritional studies have demonstrated



that these algal proteins are of high quality and comparable to conventional vegetable-protein sources (Becker, 2007). However, due to high production costs, as well as technical difficulties to incorporate the algal material into palatable food preparations, the propagation of algal protein is still in its infancy. To date, the majority of microalgal preparations are marketed as low-economic-value animal feed.

Microalgae represent a promising alternative, renewable source since they can be cultivated on non-arable land. They are normally cultivated in raceway pond systems or in bioreactors where weather conditions are less favourable. Furthermore, microalgae offer interesting applications in the field of food and functional food development as they are rich in antioxidants (Koen *et al.*, 2011), pigments (Guedes *et al.*, 2011), polyunsaturated fatty acids (Rychebosch *et al.*, 2012) and proteins (Duong *et al.*, 2015). In addition, microalgae remove and recycle nutrients from wastewater and flue-gases, thus providing additional environmental benefits. In this COST action project, we are investigating the production of non-fuel products from microalgae that could play a major role in making economic and energy balances more favourable.

#### **EUALGAE COST meeting**

The event was held in Dublin from October 14-16, 2015, and attracted researchers from 19 different EU and EU-associated countries including Serbia and Slovenia. The EUALGAE COST action proposes the establishment of a European network of scientists and industry members who share the common goal of developing an economically feasible model for the commercialisation of algae-based bioproducts. Bioproducts in question include ingredients for food, cosmetic, pharmaceutical and wastewater treatment use. EUALGAE was created to stimulate not only interaction among research groups across Europe in this research area but also to foster cooperation between academia and industry. This scientific platform will generate a synergistic approach for utilisation of microalgae biomass for sustainable foods such as proteins, fuels and fine chemical products. Topics discussed at the event included microalgae growth optimisation and population dynamics, microalgae harvest and cell wall disruption, refining of microalgae into value components, valorisation of intermediates and sub-products, and life cycle assessment of microalgae product development.

#### **Expected benefits of the action**

It is expected that EUALGAE will benefit research and development in the field of algae-based biomaterial and food production by bringing together a diverse group of researchers. Additionally,

EUALGAE will have environmental, economic and societal impacts. Environmental benefits will include potential carbon dioxide abatement by carbon uptake for microalgae growth and wastewater bioremediation by nutrient recycling or removal. Additionally, the substitution of existing products by alternative ones that are safer may reduce negative environmental impact. Economic benefits include minimising land use for microalgae culture production and energy requirements since microalgae are sun-powered microorganisms. Societal benefits include mitigation of negative impacts of current fuels. Furthermore, the development of algae bioproducts would raise the need to safeguard natural resources by elaborating public policies. Further benefits of the action include partner interactions, which will positively impact research fragmentation in the field, and coordination of research efforts to enable transfer of critical analysis of data to industry. The action will also improve knowledge concerning microalgae biomass utilisation for biochemical production and will increase European economic competitiveness by implementing new technologies and alternative bio-product generation within small and medium enterprises.

#### **Acknowledgement**

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RED

# Irish agriculture in 1916: Economics

Photos courtesy of the National Library of Ireland.

The First World War in Europe was reflected in very high agricultural prices and agricultural incomes in Ireland. The economic conditions of farmers and agricultural labourers in rural Ireland in 1916 were significantly improved on those that prevailed in the pre-war era and are unlikely to have been a key driver of the rebellion in 1916.

the year 1918 provides data on the value of agricultural exports in nominal and 1904 prices. These data allow us to create an implicit Irish agricultural export price index. Figure 1 illustrates how the value of Irish exports soared following the outbreak of the First World War; but, in contrast, the real value of exports (1904 prices) contracted by over 4% between 1914 and 1916. The stability of the real value of exports during the First World War implies that Irish agricultural output stagnated during the war. The impact of the war on the availability of imported animal feed and fertilizers undoubtedly contributed to the absence of a significant supply response. There was also a diversion of agricultural exports to domestic consumption given the impact of the war on imports of foodstuffs both from Great Britain and other countries.

## Economic fortunes of Irish agriculture in 1916

The war in Europe had a dramatic effect on Irish agricultural prices, on the value of Irish agricultural output and the profitability of Irish agriculture. Ó Gráda (1994) quotes from Patrick Kavanagh's autobiographical novel, *The Green Fool*, that during the First World War "money grew on the tops of bushes". The war closed the British market to imports from most of continental Europe (e.g., Danish butter and bacon) and the war at sea and, in particular the onset of unrestricted submarine warfare from 1917, restricted British imports from its colonies and from North and South America. Irish agricultural prices boomed as a result. Gribbon (1989) presents price data for the main cereals, potatoes, butter, eggs, cattle and sheep. Prices for all of these agricultural commodities were over 50% higher in 1916 than in 1913.

## Agri-food exports

The implicit price index of Irish agricultural exports is calculated by dividing the nominal value of Irish agri-food exports by the real export value series. From being characterised by very low levels of output and



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The Department of  
Agriculture and Technical  
Instruction in Ireland's (DATII)  
*Report on the Trade in Imports  
and Exports at Irish Ports during*

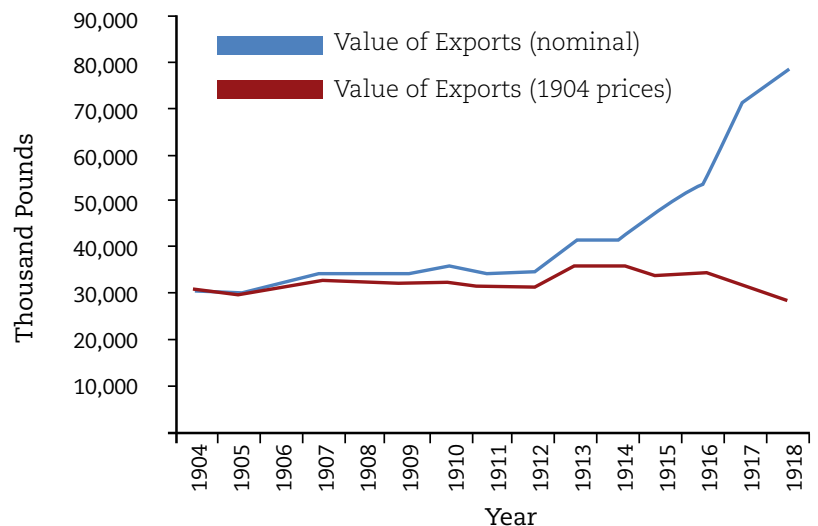


Figure 1. Irish agricultural and food exports 1904-1918.  
Source: DATII *Report on the Trade in Imports and Exports at Irish Ports during the year 1918*.

price inflation in the early years of the 20th century, the onset of the First World War led to an explosion in Irish agricultural output and also export price. By 1916, the index of agricultural export prices (1904=100) had increased to over 180 from a pre-war level of 114 in 1913.

As the experience of the Irish cattle industry in recent years has highlighted, higher prices are not always synonymous with higher profits and incomes. The prices of inputs such as purchased feed, fertilizers and limes also increased during the First World War, while general inflation significantly eroded the purchasing power of higher farm incomes. However, because agriculture in the early 20th century was less reliant on fertilizer and other fossil fuel-based inputs, there can be little doubt that average incomes in the Irish agriculture sector grew dramatically during the First World War and that they increased relative to the incomes of the urban working class.

### Farm incomes

In 1916, the income situation of Irish farmers and farm labourers was almost certainly significantly better than it had been in the pre-war era. Evidence from individual farm and estate accounts discussed by Ó Gráda (1994) suggest that income levels grew dramatically in Irish agriculture. As an example, nominal profits earned on the estate farm of Lord Clonbrock at Ahascragh in Co Galway during the period 1914-1919 were 250% higher than during the period 1910-1913.

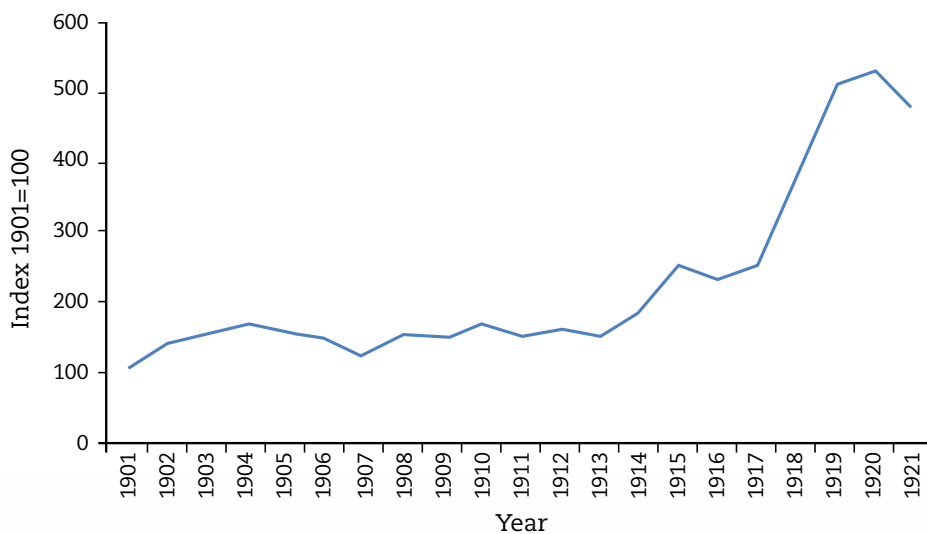


Figure 2. Agricultural land rents in Limerick (1901=100). Source: Based on data from Nunan (1987).

Evidence for the growth in agricultural incomes is also provided by evidence on how agricultural rents evolved. Higher incomes would be expected to be reflected in higher agricultural rents. In Figure 2, an index of agricultural land rental rates (1901=100), based on data from Nunan (1987), shows that by 1916 rents had increased by 24% over the level in 1914. It should be recalled that, even by 1916, the proportion of land rented was only 36%, down from 97% as recently as 1879.

### Conclusion

Irish farmers and farm labourers in 1916 almost certainly had incomes that were in excess of those they had earned during the pre-war era and their income situation relative to the non-farm population improved over the course of the First World War. It seems highly unlikely that the immediate economic conditions in rural Ireland were a major driver of the 1916 rebellion.

### References and further reading

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# When Cork ruled the (butter) world



Cork Butter Market circa 1900. Photo courtesy of the National Library of Ireland.

To commemorate 100 years of Irish independence, this article looks back at the halcyon days of the Irish butter industry, when Ireland set world prices.



The term 'world prices' gets frequent mention nowadays in discussions of prospects for milk, meat and cereals commodity markets. The term is often used with little explanation of what it means. Essentially, a world price is the price of a good that is sold on the international market, before export taxes or import duties are considered. Movements in world prices are very important since they can influence decisions that affect global supply and demand for a commodity. In the dairy sector today it is common to think of New Zealand as the country that sets the world price for dairy products. New Zealand is a very large dairy exporter and the prevailing price of its dairy commodities go a long way towards determining the prices that dairy farmers will receive for their milk in many parts of the world.

Other things being equal, farmers benefit from higher world commodity prices. When a country is designated as the world price setter for a commodity, it therefore creates considerable international interest in the capacity of that country to export the product in question. Buyers are aware that fluctuations in quality or the volume of production in the country that sets the world price will influence how much is available for

export. This, in turn, will have implications for global supplies of the product and the world price level.

While Irish dairy farmers might consider that they are at the mercy of the world market nowadays, there was, in fact a time when the world price for butter was set in Ireland. Just as it is today, back in the 18th century Munster was the heartland of dairy production in Ireland. Butter produced throughout Munster was exported through the port of Cork to many destinations internationally, to places as far away as the West Indies, the United States and much of the British Empire. Stout wooden casks, known as firkins, ensured against spoilage, even when butter was shipped to tropical regions. Together with textile production, the butter business was central to the commercial success of Cork.

## Cork Butter Market

In 1770, this led to the creation of the Cork Butter Market, located near Shandon on the north side of Cork City. Over the century that followed, the Cork Butter Market regulated the quality of butter that would be produced, enabling butter from Cork to gain a larger share of international markets. Just as is the case today, grading systems were not universally popular, with accusations on the part of some that such systems were open to manipulation.

Aided by the infrastructure created by the advent of the railway, the Cork Butter Market would go on to become the largest butter market in the world and,

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therefore, the market in which the world price for butter was set.

Butter from the Cork Butter Market was weighed in the adjacent Firkin Crane building. The building's curious rotunda shape was actually quite innovative in that it represented an appreciation for the economic advantages of an environmentally sustainable production process. The domed roof facilitated an ingenious rain water harvesting system. The harvested water was then used to wash the firkins into which the butter was packed.

### Decline of commodity prices in 19th century

Commodity prices declined in the first half of the 19th century in the aftermath of the Napoleonic Wars and this was a major setback for the market. In the aftermath of the Great Famine, an International Exhibition was held in Cork through 1852, mimicking the Great Exhibition in London of the previous year. One of the aims of the Exhibition was to reinvigorate the butter trade.

However, the position of Cork in the world butter trade went into further demise in the late 19th and early 20th century, principally due to greater competition from butter from continental Europe, especially on the lucrative British market. Advances in technology, aided by the spread of the industrial revolution across Europe, allowed France and Denmark to become prominent in the butter export market. In particular, the invention and adoption of the commercial scale cream separator allowed cream to be produced on a volume basis for the first time and led to the creation of the first creameries. These continental competitors also introduced innovations such as pre-packaged butter, which contrasted with the bulk firkin butter that was exported from Cork.

However, Ireland was slower to embrace the move towards centralised butter production. Just as the development of the Cork Butter Market imposed commodity standardisation through regulation, the move towards commercial scale butter production in continental Europe allowed for better quality control and better product standardisation. Consequently, continental European butter began to displace Irish butter in international trade towards the end of the 19th century. It was only in the 1890s, with the development of the co-operative movement under Horace Plunkett, that creameries began to spring up in Ireland, but by then, continental competitors had stolen a march on Irish butter production, which would undermine the future of the Cork Butter Market.

By the time of the Easter Rising in 1916, the future of the Cork Butter Market was growing increasingly uncertain. The advent of the First World War had made trade more difficult. Cork's 150-year dominance of the global butter trade was at an end.

By 1924 the Butter Market had ceased trading. In a curious twist, the Firkin Crane building would go on to become a margarine factory for the following 50 years. Today, the Cork Butter Market has its own museum, allowing visitors to explore the history of butter production and the impact of the butter trade on the region and its people. For more see: <http://www.corkbutter.museum/>



The Free State advertising was created by Margaret Clark. Image courtesy of Cork Butter Museum.

### Further Reading

Foynes, P. (2007) *Walking Shandon: A Guide to Cork's Historic Heart*. Cork Butter Museum Ltd., page 17.

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# Communicating the bioeconomy through images

The importance of using images to communicate the science underpinning the bioeconomy in Europe inspired the CommBeBiz Bioeconomy Photo Competition.

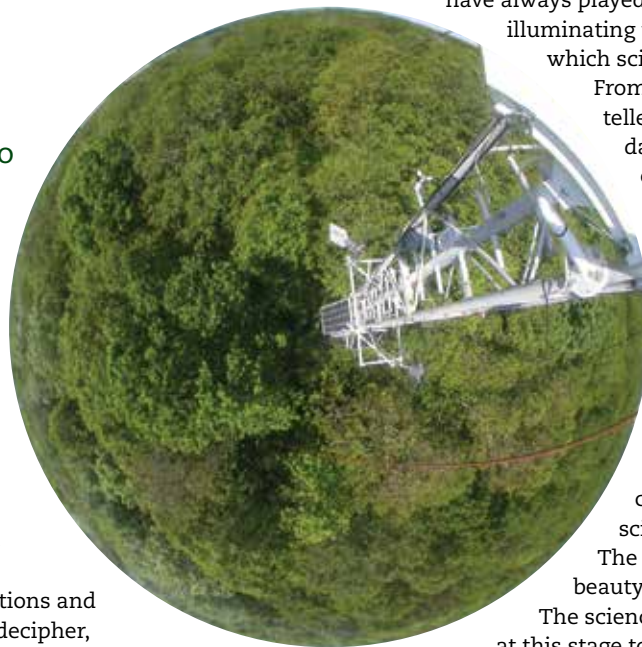


Publicly-funded researchers are increasingly expected to engage with the public about their research, but science communication can be challenging. It can be difficult to know how to convey complex ideas clearly and with impact. Where technical descriptions and graphics can be hard to decipher, a photograph can be an effective way of capturing 'the story' of a project and sharing key messages with a broad audience at a single glance. Since Leonardo Da Vinci's early drawings of human

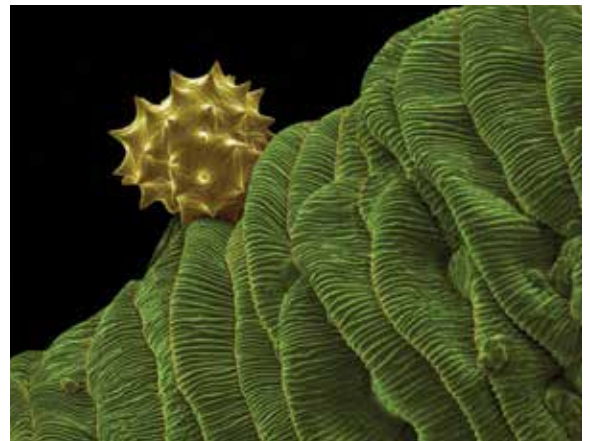
anatomy, right through to the incredible shots captured by the Hubble Space Telescope, images have always played an important role in illuminating the amazing feats of which science is capable.

From graphic designer story tellers to choreographed dances, science communication techniques have become more creative and more visual in recent years. At the SCI:COM 2015 Conference held in Athlone, science communication was described as both 'a science and an art'; and this is definitely the case for communicating science through images.

The art is obvious in the beauty of a well-taken image. The science is well established at this stage too – studies on visual information processing have time and again shown that people respond substantially better to visual information than plain text. A childhood



Finalist: Joshua Chao, NUI Galway, Ireland – The rocky shores of Galway.



Finalist: Karl Gaff, Dublin Institute of Technology, Ireland – Yarrow Micro-Spore.

## Aine Regan,

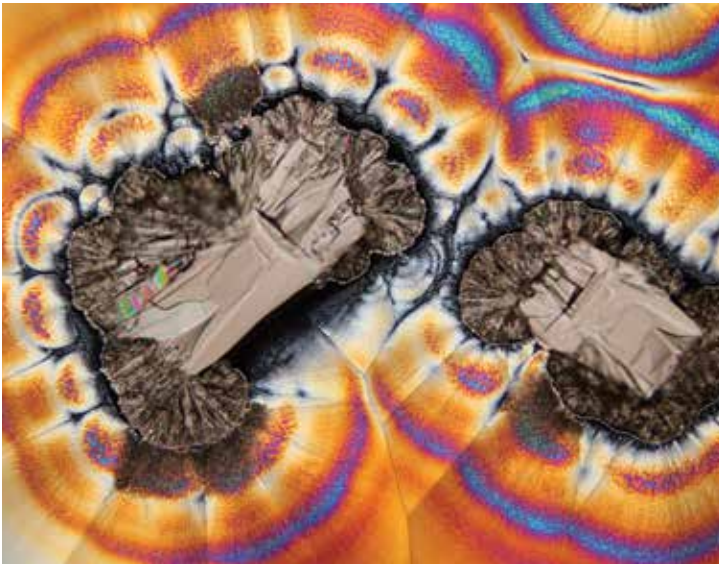
Postdoctoral Research Fellow,  
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Research Centre

## Maeve Henchion,

Head of Department of  
Agrifood Business and  
Spatial Analysis, Teagasc,  
Ashtown Research Centre,

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[aine.regan@teagasc.ie](mailto:aine.regan@teagasc.ie)



Finalist: Karl Gaff, Dublin Institute of Technology, Ireland – Dazzling Colours.

wonder takes over when we encounter new and colourful images; we want to find out more about the story of the picture – presented with images of research, we likely will find ourselves asking how and why is this research being carried out, and what's it going to achieve?

In 2015, CommBeBiz, an EC-funded project that enables effective transfer of knowledge between bioeconomy researchers, the marketplace and society, launched a photography competition to help scientists across Europe communicate more effectively with their target stakeholders, with Teagasc as proud sponsors. Researchers responded to the call and submitted their images to give an exciting insight into current bioeconomy research and innovation across Europe. Judges were tasked with the unenviable job of having to shortlist the entries and select an overall winner. The diversity of the bioeconomy is obvious in the shortlisted images: marine, forestry, food, agriculture and the transformation technologies inherent in bioeconomy development are all present. Life sciences and social sciences both feature in the shortlisted images, reflecting the need for contributions from diverse disciplines that consider both demand and supply factors in the future bioeconomy. The



Finalist: Ólafur Eggertsson, Farmer at Þorvaldseyri, Iceland – Corn production in the Arctic regions – the famous Eyjafjallajökull glacier in the background.



Finalist: Des Dolan, NUI Galway, Ireland – We've been going at this from the wrong way.

opportunities of the bioeconomy are uniquely reflected in these images: the use of marine-based products for 'smart' drug delivery; engaging with consumers to understand their role in a sustainable food future; making crop production in Iceland possible by breeding new, improved cereal varieties; highlighting the microscope as a vital research tool right across the bioeconomy sectors; and understanding the environmental impact of the construction-wood product industry in Ireland. The overall winner was announced at the CommBeBiz Conference, Bioeconomy Impact 2016, on February 11. Matthew Wilkinson's image 'Alice Holt Forest Phenology' (circular image pictured on page 38) reflects how we can monitor changes in forests and woodlands in response to climate change, research which helps inform the development of forestry policy in Great Britain. Full descriptions for each of the images and further entries are available on the CommBeBiz website: [www.commbebiz.eu](http://www.commbebiz.eu)

#### Funding acknowledgement

CommBeBiz is funded by the European Union's Horizon 2020 research and innovation programme.



Finalist: Laura Devaney, Teagasc, Ireland – A sustainable food future: outputs of the future bioeconomy.

## Events

### MARCH

March 23

RDS, Dublin

#### Teagasc Annual Distinguished Lecture Series

The lecture will be delivered by Frank Rijsberman, CEO of the CGIAR Consortium, an international agri-food research organisation that integrates the strategic research of 15 CGIAR Research Centres worldwide. It is the world's largest, publicly funded, international agriculture research partnership. Frank is responsible for driving cultural change to outcome orientation and results-based management across the system, and established the new international organisation at its new headquarters in Montpellier, France. He also refreshed the CGIAR system-wide strategy, and oversaw the creation of a new portfolio of large-scale research programmes for the period 2017-2022.

Email: [ann.tiernan@teagasc.ie](mailto:ann.tiernan@teagasc.ie) <http://www.teagasc.ie/events/lecture-series/>

### APRIL

April 11-13

DoubleTree by Hilton - Burlington Road, Dublin

#### International Dairy Federation Parallel Symposia

The International Dairy Federation (IDF) Irish National Committee (NC) is the national body representing the Republic of Ireland on the IDF and provides a consultative forum to represent at IDF scientific, technical and educational matters relating to the Irish dairy industry. The 2016 international event is organised by the IDF NC of Ireland, of which Teagasc is a member, and features two parallel symposia: The IDF Concentration and Dried Milk Products Symposium and the IDF Cheese Science & Technology Symposium.

Email: [phil.kelly@teagasc.ie](mailto:phil.kelly@teagasc.ie)

<http://www.idfingredientsandcheese2016.com/index.html>

### JUNE

June 10-11

Teagasc, Mellows Campus, Athenry, Galway

#### Farming and Country Life 1916-2016

This event, Farming and Country Life 1916-2016, seeks to commemorate the Rising and to reflect on developments in farming and country life across Ireland over the last century. The event will host a series of highly interactive villages that will explore all aspects of farming and country life in Ireland. The event will also chart the major developments in the first half of the 20th century in rural Ireland.

Contact: [1916@teagasc.ie](mailto:1916@teagasc.ie)

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

June 19-23

University of Limerick

#### Innovation Support for a Productive and Sustainable Agriculture

'Supporting the diversity and resilience of land, people and production systems' is the theme of the 2016 IALB/EUFRAS/Teagasc 2016 Conference. During the event there will be potential to engage with participants, particularly those involved in H2020 and EIP projects, and explore how to best support innovation through knowledge transfer methods.

Contact: [ialbconference2016@teagasc.ie](mailto:ialbconference2016@teagasc.ie)

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

### JULY

July 3-8

Convention Centre Dublin

#### World Buiatrics Congress

The 29th World Buiatrics Congress (WBC 2016) is the premier cattle health and production conference in the field. With between 2,500-3,000 attendees from academia, research, general practice and government services branches of the veterinary profession, as well as leading animal scientists, it is held over five days, bringing together world experts in cattle health and production systems with all the latest updates in diagnostics, animal health systems, animal welfare initiatives, food safety, zoonosis, mastitis control, parasitism, reproductive technologies and a wide range of infectious disease control programmes. The scientific committee is made up of staff from Teagasc, UCD and the Department of Agriculture, Food and the Marine.

Contact: [wbc2016@mci-group.com](mailto:wbc2016@mci-group.com)

[www.wbc2016.com](http://www.wbc2016.com)

July 5

Teagasc, Animal & Grassland Research and Innovation Centre, Grange

#### Teagasc National Beef Open Day

The theme of Teagasc's National Beef Open Day is 'Beef 2016: Profitable Technologies'. Set against a backdrop of Ireland being the fifth largest beef exporter in the world and the largest exporter of beef in Europe, the value and importance of the sector to both the national and local economies cannot be underestimated. Attending this event is a necessity for all beef farmers and stakeholders in the Irish beef industry.

E-mail: [edward.oriordan@teagasc.ie](mailto:edward.oriordan@teagasc.ie)

<http://www.teagasc.ie/events>

### AUGUST

August 21-25

RDS, Dublin

#### IUFoST 2016 World Congress of Food Science and Technology

The International Union of Food Science and Technology (IUFoST) is the global scientific organisation for food science and technology supporting programmes and projects to increase the safety and security of the world's food supply. Throughout more than 65 member countries, it represents over 300,000 food scientists and technologists worldwide. Its 2016 conference is themed 'Greening the Global Food Supply Chain through Innovation in Food Science and Technology'.

Contact: [info@iufost2016.com](mailto:info@iufost2016.com)

<http://www.iufost2016.com/>

### OCTOBER

October 19-21

University College Dublin

#### 10th International Life Cycle Assessment of Food Cycles 2016

The conference is structured into four broad themes. The first will look at specific environmental processes and services as addressed by life cycle assessment (LCA) including soil, biodiversity, ecosystem services, water and land use. Theme two will look specifically at animal agriculture with contributions on dairy, beef, pigs and poultry, post-farm processing and whole chain studies. Theme three will look at interaction with humans and human systems including contributions on crop systems, waste, processing, diet, nutrition, behaviour, and health and food innovation. Theme four will address various aspects of how life cycle assessment (LCA) is used, with contributions ranging from data, methods and tools, through socioeconomic methods, to PEF, labelling and policy.

Contact: [sinead.lawlor@conferencepartners.ie](mailto:sinead.lawlor@conferencepartners.ie)

<http://cafood2016.org/programme/>

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/>