TEAGASC

Research

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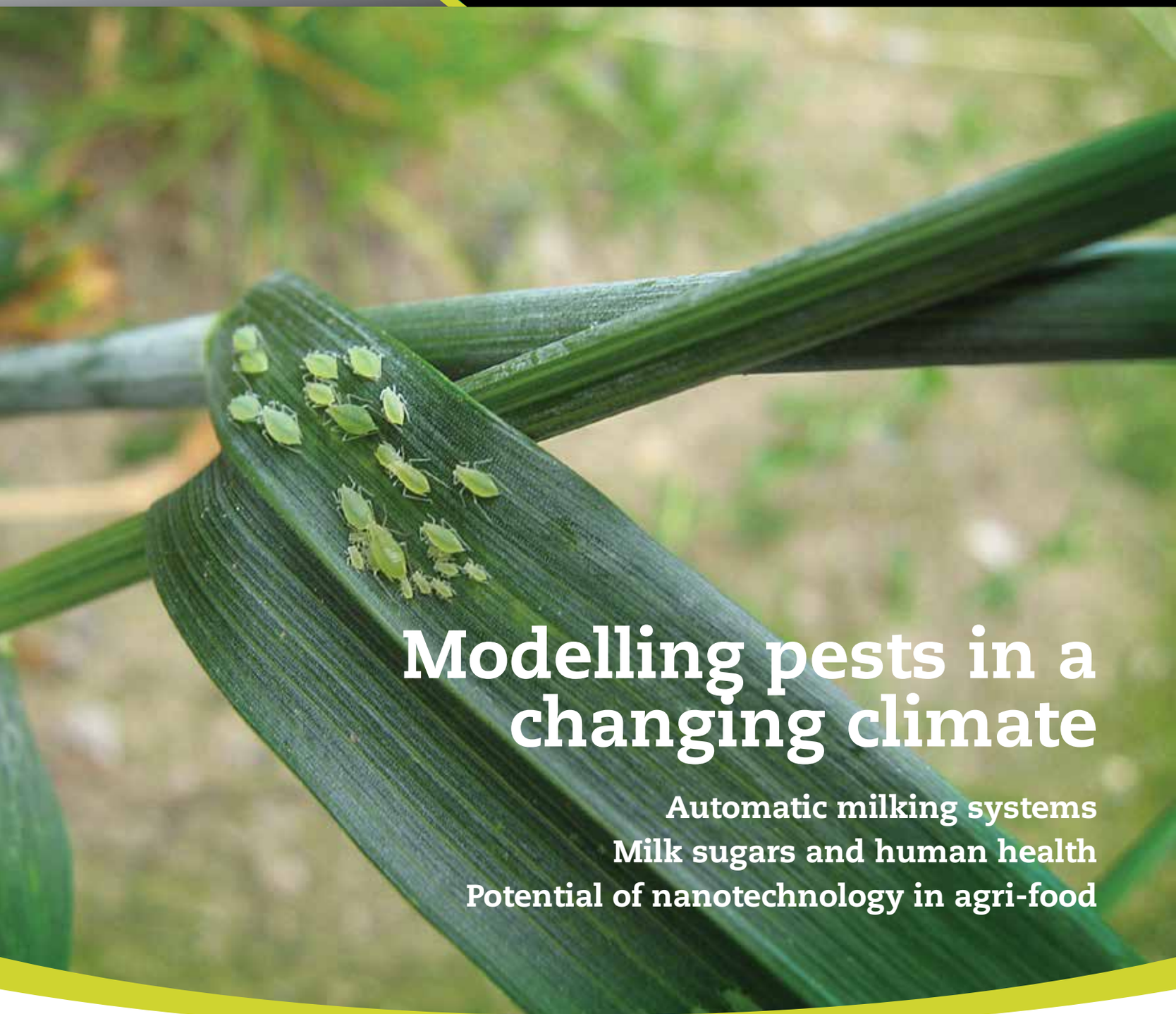

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EDITOR Catriona Boyle 059-918 3419 catriona.boyle@teagasc.ie
SUBSCRIPTIONS: alison.maloney@teagasc.ie

Commercialising research results

There has always been a need for public research programmes to have significant societal, economic or other tangible benefits. A major new report by the OECD, on commercialisation of results from public research, emphasises that there are many gateways to achieve this. Public research organisations, like Teagasc, play a very significant role in the so-called innovation eco-system. Greater awareness of the substantial economic benefits from public research (and greater demand by Governments to reap the benefits) has led to increased efforts towards commercialisation activities (OECD, 2013). The drivers for this include the need to improve competitiveness in industry, the increasing cost of scientific research and the requirement for public bodies to develop measurable returns from public research results.

The measurement of the appropriate metrics, relating to effective impact, is the subject of much debate. Patents, licencing and spin-offs remain as important metrics; but others, such as collaborative research partnerships, contract research agreements, student/researcher mobility and commercial service arrangements are increasing in importance (OECD, 2013). Furthermore, scientific publications and conferencing/networking are two other important and effective means to enhance impact.

As part of the Teagasc 'Food Technology and Knowledge Transfer Strategy' we have incorporated these metrics as part of our normal business planning.

To be even more effective in this activity, Teagasc has established a Customer Relationship Management (CRM) system, whereby many of our food researchers also act as Key Account Holders for our major food clients. In this way, companies find it easier to do business with us.

Teagasc has developed a 'live' Technology Portfolio that is accessible online (http://bit.ly/1gGMmbw), in hard copy and presented at our Gateways events. It describes our current portfolio of technologies including our IP offers, latest updates from our research programme, specialist technology services, our expertise areas and, most of all, our researcher profiles (including their specialised skills).

Along with our now branded Gateways Events, and our participation in Enterprise Ireland-funded Technology Transfer Strengthening Initiative, Teagasc will ensure that the results of our research are proactively managed, and that the greatest return (economic or otherwise) is gained from our research projects for the benefit of the nation and in line with the OECD recommendations.

Declan Troy
Assistant Director of Research and
Director of the Technology Transfer Office

Reference

OECD (2013) *Commercialising Public Research: New Trends and Strategies*, OECD Publishing

Torthaí taighde a thráchtálú

Bhí gá ann i gcónaí le tairbhí suntasacha sochaíocha, eacnamaíocha agus inláimhsithe eile a bheith ag cláir taighde phoiblí. Tugtar chun suntais i mórthuarascáil úr atá déanta ag an ECFE maidir le torthaí ó thaighde poiblí a thráchtálú go bhfuil go leor bealaí ann chun é sin a bhaint amach. Tá ról an-tábhachtach ag eagraíochtaí taighde phoiblí amhail Teagasc san éiceachóras nuálaíochta mar a deirtear leis. Mar thoradh ar fheasacht mhéadaithe ar na tairbhí suntasacha eacnamaíocha a fhaightear ó thaighde poiblí (agus an t-éileamh méadaithe ó Rialtais na tairbhí a bhaint as) tá méadú tagtha ar na hiarrachtaí i dtreo gníomhaíochtaí tráchtálaithe (ECFE, 2013). Taobh thiar den mhéid seo tá an gá le feabhas a chur ar iomaíochas sa tionscal, an costas ar thaighde eolaíochta atá ag méadú agus an ceangal ar chomhlachtaí poiblí torthaí intomhaiste agus dhíreacha a fhorbairt ó thorthaí taighde phoiblí.

Tá tomhas na méadrachtaí iomchuí a bhaineann le tionchar éifeachtach á phlé go mór. Tá paitinní, ceadúnú agus seachtháirgí fós ina méadrachtaí tábhachtacha; ach tá cinn eile, amhail comhpháirtíochtaí taighde comhoibríocha, comhaontuithe taighde conartha, soghluaisteacht mic léinn/taighdeoirí, comhaontuithe seirbhís tráchtála (lena n-áirítear cúrsaí oiliúna agus soláthar comhairleachta) ag éirí níos tábhachtaí (ECFE, 2013). Lena chois sin, is dhá mhodh éifeachtacha eile iad foilseacháin agus comhdháil/líonrú eolaíochta chun an tionchar a mhéadú.

Mar chuid de straitéis Teagasc 'An Straitéis um Theicneolaíocht Bia agus Aistriú Eolais' chuimsíomar na méadrachtaí sin mar chuid dár ngnáthphleanáil ghnó.

Lena bheith níos éifeachtúla sa ghníomhaíocht sin, bhunaigh Teagasc córas Bainistíochta Caidreamh Custaiméirí (CMR), trína ngníomhaíonn a lán dár dtaighdeoirí bia mar Phríomhshealbhóirí Cuntais dár bpríomhchliaint bhia. Ar an dóigh sin tá sé níos éasca do chuideachtaí gnó a dhéanamh linn.

D'fhorbair Teagasc Punann Teicneolaíochta "bheo" ar a bhfuil fáil ar líne (http://bit.ly/1gGMmbw), i gcóip chrua agus a thugtar amach ag ár n-imeachtaí Gateway. Déantar cur síos inti ar ár bpunann reatha teicneolaíochtaí, lena n-áirítear ár dtairiscintí IP, na tuairiscí is déanaí ónár gclár taighde, seirbhísí teicneolaíochta speisialaithe, ár réimsí saineolais, agus, thar aon ní eile, próifílí ár dtaighdeoirí (lena n-áirítear a gcuid scileanna speisialaithe).

Mar aon lenár n-Imeachtaí Gateways atá brandáilte anois, agus ár rannpháirtíocht sa Tionscnamh um Neartú Aistrithe Teicneolaíochta arna mhaoiniú ag Fiontraíocht Éireann, cinnteoidh Teagasc go ndéanfar torthaí ár dtaighde a bhainistiú go réamhghníomhach, agus go bhfaightear an toradh is fearr (eacnamaíoch nó eile) ónár dtionscadail taighde chun tairbhe an náisiúin agus i gcomhréir le moltaí an ECFE.

Declan Troy
Stiúrthóir Cúnta Taighde agus
Stiúrthóir na hOifige um Aistriú Teicneolaíochta

Tagairt

ECFE (2013) *Commercialising Public Research: New Trends and Strategies*, Foilseoireacht ECFE.

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Scan with QR code reader

Dr Aidan Moloney

Dr Aidan Moloney is a Principal Research Scientist in the Animal and Bioscience Research Department at Teagasc, Grange, Co Meath, where his research programme explores the relationships between production factors, in particular nutrition, and the appearance, nutritive value and sensory quality of beef.

Dr Moloney explains that what people look for in beef depends on where they are along the supply chain. While farmers aim to get a good price from the factory, based mainly on the weight and quality of the carcass, the consumer is more concerned about paying for qualities such as tenderness, flavour and appearance. Since Ireland exports about 90 per cent of its beef, bridging the gap between these priorities is an important task. Dr Moloney says that how animals are managed on the farm has implications throughout the beef chain. "So, for the industry to remain competitive there has to be joined-up-thinking."

Dr Moloney completed his PhD in Biochemistry from University College, Galway in 1984. Following this, he was recruited by An Foras Taluntais (the predecessor of Teagasc) and received further training at the Grassland Research Institute, in Hurley, England, before taking up a research position with Teagasc. Between October 1993 and November 1994, Dr Moloney went on a sabbatical visit to Cornell University, Ithaca, New York, US, where he studied protein-induced gene expression in beef cattle.

Aidan has published extensively on various aspects of growth, digestion and meat quality in the growing ruminant. He led the Irish contribution to an EU 5th Framework project concerned with improving the healthiness of beef from a consumer perspective (HealthyBeef); the cattle growth component of the FIRM projects: 'Enhancing the healthiness, shelf-life and flavour of Irish beef'; and 'Biomarkers to authenticate Irish grass-fed beef'. He also coordinated the FIRM project: 'Healthy fatty acid-enriched fresh beef: Implications for shelf-life, flavour and the health of the consumer' and many Teagasc core-funded projects. He was a participant in the EU FP6 projects TRACE (http://www.trace.eu.org/) and ProSafeBeef (http://www.prosafebeef.eu).

He currently coordinates the FIRM/RSF project 11/RSF/322 (Profitable production of bull beef to market specification while ensuring optimum quality for the consumer).

Aidan is also senior editor of Teagasc's peer reviewed publication the *Irish Journal of Agricultural and Food Research*.

JDS article of the month

A paper by Teagasc researchers features as March's article of the month in the *Journal of Dairy Science*. 'Milk production and enteric methane emissions by dairy cows grazing fertilized perennial ryegrass pasture with or without inclusion of white clover', is lead authored by Daniel Enriquez-Hidalgo, a Teagasc Walsh Fellow based at Moorepark and co-authored by Dr Trevor Gilliland, AFBI; Matthew Deighton (formerly Teagasc Moorepark, now Department of Environment and Primary Industries, Australia), Dr Michael O'Donovan and Dr Deirdre Hennessy, both Teagasc Moorepark. The paper has been selected as a highlighted article of the month by the editor-in-chief, Roger Shanks, and will be featured prominently on the journal's home page. The paper can be accessed at http://www.journalofdairyscience.org/article/S0022-0302(13)00878-3/abstract

A new direction for sheep breeding

Sheep production is a significant contributor to the agricultural and national economy with an output valued at €209 million, with about 80% of this exported. This was one of the key messages at the Teagasc National Sheep Conference that took place in Athlone and Letterkenny in February.

Dr John McEwan, from AgResearch in New Zealand spoke about the future prospects for genetic improvement in sheep. He pointed to the gains that genetics has already delivered in terms of increased numbers of lambs born, improved lamb survival, higher weaning weights, heavier carcass, reduced carcass fat, and heavier fleeces. Teagasc researcher, Dr Noirin McHugh said that genetic evaluations are a powerful tool for sheep farmers enabling them to make more informed breeding decisions and potentially increase productivity and profitability at farm level.

At the Teagasc national sheep conference are: Ciaran Lynch, Research Technologist, Teagasc, Athenry; Dr Noirin McHugh, Animal and Bioscience Research Department, Teagasc Moorepark; and guest speaker Dr John McEwan, AgResearch New Zealand, who spoke about the future prospects for genetic improvement in sheep.

International food security

The Department of Foreign Affairs recently undertook a review of Ireland's foreign policy. Teagasc, in its submission, highlighted the importance of food in our external interactions:

- Food production is one the global grand challenges; given population growth, climate and other environmental challenges, provision of sufficient food and nutrition.
- Food shortages, as a result of recent food price spikes have been a source of global instability.
- Food is one of the world's largest traded commodities.
- Food is Ireland's largest indigenous export sector.
- Food has highly-complex, globally-integrated supply chains.
- Food and agriculture are the largest policy area within the EU.
- Food production, when produced with insufficient quality standards, can be a source of global bio-security risk.
- Food is intrinsically related to Ireland's self-image and is used to promote and market other sectors.
- Food security is a very important part of Ireland's development strategy.

The Hunger Task Force has called on all areas of Government to input into a national hunger strategy, while the Government's 'One World, One Future' strategy has called for a whole-Government approach. In facilitating this objective Teagasc has:

- Established a Food Security Committee and Strategy.
- Prepared an MOU with Irish Aid to maximise Teagasc's effectiveness.
- Teagasc, in association with the RDS, has organised a series of public lectures in relation to the growing challenges of sustainably meeting the food security needs.
- Undertaken a number of targeted projects such as the Ethiopia Potato Project and advice to the Tanzanian government in establishing an integrated advisory service.

From a research and development point of view, greatest synergies are possible where technologies and methodologies are most transferable.

- Agricultural systems with North-South complementarities such as the potato.
- Strategic planning and foresight.
- Agricultural knowledge transfer, extension and education.
- Food supply chain.
- Farmer and value change organisations and structures.
- Specific technologies such as bio-sciences, information technology and SMART agriculture, economic modelling, remote sensing and GIS.

The full submission can be found on www.teagasc.ie/publications/

Futurology

Minister for Agriculture, Food and the Marine, Simon Coveney, TD, launched the recent 'Futurology' module of the Agri-Food Graduate Development Programme (UCC, UCD and Teagasc), which was attended by over 50 postgraduate researchers, as well as industry representatives. The AFGDP is funded by the Department of Agriculture, Food and the Marine, and holds monthly training events for agri-food postgraduate researchers. The AFGDP management team is pictured along with the Minister: Dr John Finn, Teagasc; Professor Dolores O'Riordan, UCD; Julie Dowsett, UCD; Professor Alan Kelly, UCC; and Dr Joanne Fearon, UCC.

Improving precision and profit on tillage farms

Speaking at the Teagasc National Tillage conference in Kilkenny recently, researcher Dermot Forristal, said precision agriculture can be considered in two categories – managing within-field variability and machine guidance. He said that managing spatial variability involves the gathering and mapping of information from different parts of the field and using GPS systems to give locations and computer applications to generate yield and soil nutrient maps. He said that machine guidance systems such as 'auto steer' and GPS controlled headland management systems have made significant strides both in development and adoption.

UK-Ireland Summit report

Teagasc and the Institute of Food Research (IFR), supported by a number of other UK and Irish partners, organised the first UK-Ireland Food Business Innovation Summit in Dublin on May 29, 2013. The views and conclusions of the Summit have now been captured in a report entitled 'Innovation in the Ireland and UK Food Sector: Ambitions for Action' (http://teagasc.ie/businesssummit/InnovationIrelandUKFoodSector.pdf).

The event brought together leading UK and Irish food company executives and retailers, along with policy makers, research managers and educationalists to debate key challenges and opportunities for innovation in the agri-food sector in both countries. The Summit was seen as a positive step towards building closer cooperation between the two islands, reflecting the comments made by the Taoiseach, Enda Kenny and the Prime Minister, David Cameron in March 2012.

The above-mentioned report proposes three 'Priority Actions' to drive the UK-Ireland innovation, education and entrepreneurship collaboration using an integrated approach. They include the establishment of an Ireland-UK food-sector Hub that will work to improve the competitiveness of the food industry and pioneer a UK/Ireland 'ecosystem for entrepreneurship'. Both Teagasc and IFR are committed to engaging with the governments of both countries, along with other stakeholders, to collaboratively deliver these priority actions.

For further information relating to the summit, the outcomes and actions, and emerging plans for a second bilateral food sector event please consult http://teagasc.ie/businesssummit/

Long-term land use strategies

Teagasc experts Dr Rogier Schulte and Reamonn Fealy at a recently informed the Oireachtas Joint Committee on Agriculture, Food and the Marine that, while Ireland's land base is probably sufficient to meet the demands of our ambitious food targets up to 2020, careful consideration to policy decisions will be required to ensure appropriate land use in the longer term to 2050.

Over a series of hearings, the Committee is hoping to examine the most appropriate mix of policies to maximise the potential of Ireland's diverse lands. Chairman of the Committee, Andrew Doyle, TD says: "There are few greater challenges for our €10 billion agri-food industry than charting a sustainable and balanced land-use strategy in the longer term. Making the right choices now has the potential to positively influence generations of farm families well into the future. While it is an issue that transcends the current Dáil term, our Committee is expecting to examine the current policy options in the area with key stakeholders and experts in the coming months."

He went on to say: "The Committee was told of the research being undertaken on Irish soil, with detailed mapping and databases on regional soil types coming on stream shortly. This work is expected to feed into policy making in the area, to ensure that soil types are used most appropriately and efficiently across the country. We were told of the four key demands for our land, namely, increasing food production under *Food Harvest 2020*, offsetting carbon, the provision of clean water and lastly, the protection of habitats for biodiversity. In order to achieve these four goals, more efficient management of the resource is essential."

For more see: http://bit.ly/1gURJUC

ERA-NET meeting

Dr Raymond Kelly, Teagasc, in discussion with Niels Gøtke, Head of Division in the Danish Agency for Science, Technology and Innovation (DASTI) at a recent conference on ERA-Net Initiatives – Joint Research for Europe, hosted by the German Federal Office for Agriculture and Food in Berlin. Dr Kelly chaired the session on 'Networking, Partnering, Benefit'.

BTYSE

Brian McGuinness, Plant Pathology, Teagasc Ashtown Food Research Centre with BT Young Scientist winner Anna McEvoy. Her project entitled: The aetiology of bleeding canker disease of horse chestnut trees, was carried out in the new plant pathology laboratories in Ashtown under Brian's supervision. She won first prize in the senior biological and ecological category, as well as the Elan award. This is the second year in a row she has come first in this category.

Economic analysis of rural towns

Teagasc Head of Rural Economy and Development, Professor Cathal O'Donoghue presented research undertaken as part of Teagasc's research support of the Commission for the Economic Development of Rural Areas (CEDRA) to a recent meeting of Galway County Council. At this meeting Professor O'Donoghue said: "Small- and medium-sized towns have been affected to a greater extent by the economic downturn, with unemployment increasing by 193% in towns under 10,000 inhabitants compared with 115% in cities and 150% nationally."

He noted in his address that:

- Education levels are lower than the national average in small- and medium-sized towns and the open countryside.
- Small- and medium-sized towns and the open countryside are disproportionally reliant on declining industrial sectors (construction, manufacturing industry).
- Poverty rates are higher in small- and medium-sized towns.
- The share of working age households with no one in work (jobless households) is 20% higher than the national average at 31%.

OECD fellowship

Pictured at the Centro de Investigación y Tecnología Agroalimentaria de Aragón in Spain are: Dr Maeve Henchion, Head of Department, Agrifood, Business and Spatial Analysis, Rural Economy Development Programme, Teagasc and Dr Azucena Garcia. Dr Garcia will be visiting Teagasc Ashtown on an OECD Fellowship this summer for two months to research 'Public perceptions of new processed food products with improved nutritional and health characteristics'.

Eco Eye

Dr Dermot Forristal, Research Officer, Teagasc Crops, Environment and Land Use Research Centre, Oak Park, Carlow with Eco Eye broadcaster Duncan Stewart on an episode entitled: The Future of Farming, on RTÉ recently. This episode can be viewed on YouTube: http://www.youtube.com/user/TeagascMedia

Expertise offers

Teagasc, through its Food Research Centre at Moorepark, can provide technological expertise and state-of-the-art facilities, which, combined, offer clients access to a range of innovative processing solutions, including spray drying, which can be used to develop and stabilise ingredients.

Bio-functional Food Engineering facility

Funded through a Department of Agriculture, Food and the Marine fund – the FIRM Strategic Equipment Fund 2006 – the Bio-functional Food Engineering (BFE) facility is a state-of-the-art facility for food technologists to process and stabilise ingredients for use in nutritional beverages, including infant formula. Designed to fast track the transfer of ideas from the laboratory to pilot plant, the range of unit operations offered by BFE covers areas such as dehydration, separation, encapsulation and thermal processing.

Benefits to industry

The BFE facility provides a one-stop facility for dairy-based beverage applications. It has unique, fully-integrated research pilot scale fermenters/reactors and processing capabilities with easy access to scale-up equipment at Moorepark Technology Ltd. (MTL). The equipment has been carefully matched to allow transfer of product from one bench scale process to the next, providing a highly flexible processing environment where the goal is high throughput of experiments with complex design. The BFE provides a technological platform for use by industry at the near market stage. Ultimately, it is expected that the facility will make a key contribution to the development of foods and beverages containing bio-active ingredients with proven stability and shelf-life.

Facilities/equipment

- Multi-stage spray dryer with fluidising capabilities capable of drying milk-derived components.
- Multifunctional membrane filtration plant suitable for separating milk and ingredients.
- Supercritical fluid extraction.
- Adsorber chromatography unit.
- Continuous decanter centrifuge for concentration and purification of bioactive substances post-fermentation, precipitation and hydrolysis of dairy and plant materials.
- Concentric nozzle encapsulator for microencapsulation of bio-active components 10-1,000µm.
- Microthermics heat exchanger and in-line homogeniser

Of interest to

- Dairy and food industry.
- Ingredient and infant formula manufacturers.

Development of ingredients using spray drying

Ongoing adaptation of the spray-drying process is extending beyond milk to the wider food ingredient sector. The know-how and facilities are available at Teagasc to address most client demands in spray drying for the purpose of ingredients development.

Benefits to industry

Through engaging with Teagasc, access to state-of-the-art facilities and extensive expertise in ingredient evaluation and development is available to offer companies a range of innovative processing solutions, including:

- Powders for food service applications
  - Coffee-stable powders, imitation creamers.
- Powders for nutritional applications
  - Evaluate ingredient behaviour on end-product stability.
  - Intermediate ingredient pre-mixes with defined performance.
  - Stabilised mineral fortified powders.
  - High protein ingredients for sports nutrition use.
  - Protein hydrolysates.
- Business-to-business tailored ingredients
  - High fat and microencapsulated fat-containing powders.
  - High free fat powders for chocolate applications.
  - Yogurt and other fermented powders.
  - Powders customised to client needs.

Facilities/equipment

- Pilot processing facilities.
- Moorepark Technology Ltd.
- Tall-form spray drying-Niro TFD-20 pilot scale drier to industrial specifications.
- Reconstruction processor, separation processor, evaporator and heating systems.
- Analytical facilities for analysis of powders.

Range of solutions

Teagasc can provide a range of solutions including:

- Evaluation of scale-up considerations during drying of new ingredients.
- Provision of innovative milk powder ingredients for evaluation.
- Evaluation and diagnosis of ingredient performances in spray dried formulations.
- Optimisation of pre-processing treatments.
- Analysis of powders.
- Advice on quality and food safety issues.

For further information please contact:
Dr Mark Fenelon, Head of Food Chemistry and Technology Department,
Teagasc Food Research Centre, Moorepark. Email: mark.fenelon@teagasc.ie

Pictured at the annual Walsh Fellowships seminar are winners Patrick Gillespie, Daniel Cavanagh and Shane Kennedy.

Teagasc Walsh Fellowships winners

Teagasc's annual Walsh Fellowships seminar gives fellows near the completion of their doctorate programme the opportunity to present the results of the projects to their peers and a broader audience.

The 18th annual Teagasc Walsh Fellowship Seminar 2013 took place in the RDS last November. Thirteen young researchers presented the results of their research, with a further 33 postgraduate students publishing posters.

Opening the seminar, Teagasc Director, Professor Gerry Boyle said: "The Walsh Fellowship Programme has proved to be remarkably effective in meeting the training needs of young graduates and directing them into high-grade employment in industry, academia and the wider public sector. Through ongoing adaptation to the changing scientific and industrial environment, Teagasc will ensure that the Programme continues to address new challenges and opportunities as they arise."

Overall winner

The winner of the Walsh Fellowships seminar and the RDS medal was Patrick Gillespie, who presented a paper on 'Grass utilisation as a driver of efficiency on European dairy farmers'. Patrick is a Walsh Fellow at the Teagasc Rural Economy Research Centre in Athenry and the National University of Ireland Galway.

Best poster

The winner of the best poster was Shane Kennedy for his poster on 'Grain number m^2 in barley – how much is too much?' Shane is a Walsh Fellow based at Teagasc Crops Research Centre, Oak Park and at SRUC Edinburgh in Scotland.

IFSTI medal

The Institute of Food Science and Technology Ireland (IFSTI) medal was presented to the best food science and technology presentation. This was won by Daniel Cavanagh for his paper on 'From fields to fermentation': characterisation and application of non-dairy cultures in dairy foods'. He is based at the Teagasc Food Research Centre in Moorepark and University College Cork.

Guest speaker Professor Mark Ferguson

Professor Mark Ferguson, Director General of Science Foundation Ireland (SFI) and Chief Scientific Adviser to the Government, delivered the keynote address to the seminar. He stressed the importance of excellent science on the one hand and the impact of the research for industry on the other. All of the funding for research provided by SFI is done on a competitive basis and everything is internationally peer reviewed. Professor Ferguson emphasised the importance of Ireland doing well out of the Horizon 2020 EU research funding programme. He said Irish researchers should aim to compete for and win greater than €1 billion in funding from Horizon 2020.

Opportunity to fund Walsh Fellowships

Teagasc also launched a new form of Walsh Fellowship during the Seminar, which will provide philanthropists, business and industry with a valuable opportunity to fund agri-food research by establishing a Walsh Fellowship for a donation of €66,000 (for a three-year PhD programme) or €88,000 (for a four-year PhD programme).

Speaking at the launch, Dr Noel Cawley, Chairman of Teagasc, said: "Benefactors will now have an opportunity to support the work of Teagasc and the agri-food sector in a tax-efficient manner by funding a young scholar who will help add new knowledge for the sustainable development of our agriculture and food processing industry. This is a very important initiative for Teagasc in seeking tax-efficient funding in supporting its mission."

Articles by the winners in each category are in the following feature pages.

Grass use and cost efficiency

What effect does increased grass use have on the cost efficiency of specialist milk producing farms across a range of European countries? Patrick Gillespie was awarded the RDS medal for Best Presentation at the Teagasc Walsh Fellowships 2013 seminar for his presentation on this topic.

Patrick Gillespie, Teagasc Walsh Fellow.
Dr Fiona Thorne, Senior Research Officer, Agricultural Economics and Farm Surveys.
Dr Thia Hennessy, Head of Department, Agricultural Economics and Farm Surveys.
Professor Cathal O'Donoghue, Head of Programme, Rural Economy and Development Programme.
Dr Stephen Hynes, National University of Ireland, Galway.
Correspondence: patrick.gillespie@teagasc.ie

Experimental data has shown that – when properly managed – grass can improve milk quality, reduce greenhouse gas emissions, and even increase profitability on dairy farms (Kennedy *et al.*, 2005; Lovett *et al.*, 2008). This research complemented those studies by using the internationally harmonised data of the Farm Accountancy Data Network (FADN), of which Teagasc is a partner. The dataset records actual farm accounts from specialist dairy farms in a selection of countries, which was used to examine the impact of grass utilisation on dairy (cash cost) efficiency.

This work forms one of Teagasc's many contributions to the EU FP7-funded 'Multisward' project, which Teagasc participates in along with 14 other research organisations from across Europe. This study adds a microeconomic analysis of the efficiency of grass to the project.

The Stochastic Frontier (SF) breed of advanced econometric models was chosen for this analysis, having been at the forefront of the literature in recent years. According to this method, the combination of costs, outputs, and input prices for individual farms were compared to the most efficient farm observed. The model then generated a measure of cost efficiency that represented the 'distance' to full efficiency, but it was also sophisticated enough to distinguish between inefficiency and random variation among the farm data.

The results on Table 1 confirm that increased grass utilisation reduced the distance to full efficiency in Ireland and France, but it had the opposite effect in Germany and Wales. Farms were also grouped on the basis of bio-geographic zones. The grass effect improved cost efficiency in the Atlantic Plains zone, but worsened it in the Continental Europe zone. The associated p-values are low enough to establish the statistical significance of the grass effects.

The results were in line with prior expectations barring the direction of the Welsh grass effect. This result was counter-intuitive given the importance of grass input in Wales, and its location in the Atlantic Plains zone.

Table 1: The effect of grass on the distance to full efficiency.

Cost frontiers	Grass efficiency effect	p-value
Germany	4.540	0.061
France	-0.043	0.000
Ireland	-0.100	0.000
Wales	0.017	0.002
Atlantic Plains	-0.052	0.007
Continental Europe	0.006	0.048

Source: Authors' calculations.

The model estimated efficiency in managing short-run cash costs, so differences in systems and fixed costs may explain the widely varying estimates of the grass effect.

The literature suggested that there were benefits to increased grass utilisation, which would have been unaccounted for in this study, and yet estimates still showed an average benefit in Ireland, France, and in the Atlantic Plains zone.

In summary, there was some statistical evidence that grass drives cost efficiency in some countries and bio-geographic zones, but not in all of them. Structural differences in production systems are a likely cause, and this was exemplified by the surprising Welsh results. Future research will include fixed costs.

This research is funded by the FP7 Multisward project (www.multisward.eu) and the Teagasc Walsh Fellowship scheme.

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Grain number in barley

Shane Kennedy was awarded best poster presentation at the Teagasc Walsh Fellowships seminar for his research on 'Grain number per m^2 in barley – how much is too much?'

Shane Kennedy,
Walsh Fellow, Teagasc, Crops, Environment and Land Use Programme, Oak Park Crops Research Centre, Co Carlow.
John Spink,
Head of Crop Science Department., Teagasc, Crops, Environment and Land Use Programme, Oak Park Crops Research Centre, Co Carlow.
Dr Ian Bingham,
Reader in Crop Physiology, Crop & Soil Systems Research Group, SRUC, West Mains Road, Edinburgh, UK.
Correspondence:
shane.kennedy@teagasc.ie

Barley is a grain crop, which is predominantly used for animal feed and by the brewing industry. Ireland, as a result of its temperate maritime climate, achieves the second highest yields per hectare of barley in the world. Optimising the performance of crops in areas of high yield potential is important to meet future increases in food demand, while minimising global land use change.

Through photosynthesis, crops use the energy from light to fix CO_2 and, in the process, convert it to chemical energy stored in organic matter, the dry matter of the plant tissue. Over half of this is stored as starch in the grains. These grains are the marketable end product. Evidence from this and other work suggests that barley has the potential to create more dry matter than it does grains to store it, similar to a beer factory that is producing large amounts of liquid beer but doesn't have enough bottles to put it in. This suggests that output (yield) can be increased by managing or breeding for crops of increased grain number or greater storage capacity per grain.

Grain storage capacity

At higher grain numbers, the capacity of the grains to store dry matter could be compromised. Grain storage capacity is considered to be determined by the amount of cell division that occurs during a two- to three-week period between grain fertilisation and the start of rapid grain filling. During this period, crop canopies are already intercepting most of the available light. Any increase in grain number would, therefore, result in less light being intercepted per unit grain number, which may impact negatively on cell division and, consequently, grain storage capacity. Thus, reduced grain storage capacity at higher grain numbers could, in theory, result in no further yield increase.

Field trials

A series of replicated field trials in crops of spring-sown barley (cv. Quench) were carried out at Oak Park, Co. Carlow in 2012 and 2013 to determine the effects, on grain growth, of light availability per unit grain number during early grain development. Two separate treatments were employed: a light reduction was achieved by suspending shade netting over known areas of crop and a light increase per plant was achieved in certain row lengths by pulling back adjacent rows. Treatments were applied for the two-week period where grain storage capacity is supposed to be determined and then removed resulting in a return to ambient solar radiation levels for the remainder of the grain-filling period. Final grain weight was assessed and compared to that in plots that received ambient solar radiation levels throughout. Treatments had no statistically significant effect on mean grain weight at harvest – it was neither increased by the additional light nor decreased due to shading. This indicates that either the grain storage capacity of Irish barley crops is not sensitive to growth conditions during this period, or that grain storage capacity is determined elsewhere in the crop lifecycle.

Increasing grain number

The lack of a reduction in final grain weight due to shading may be due to a buffering of grain assimilate supply during endosperm development by stem storage reserves. These stem reserves are accumulated in the form of sugars during periods when dry matter production exceeds the demand for growth within the crop. In 2013, these reserves peaked at 1.2t/ha of stem sugars. This 'hidden' resource, which is available alongside continued photosynthesis during the grain-filling period, bolsters the argument that there is an excess of potential dry matter for grain filling. Further work has shown that crops with large potential grain numbers are unlikely to abort additional grains. Overall, evidence supports the theory that increasing grain number will increase yield.

The work was funded by the Teagasc Walsh Fellowship Programme.

Manipulating light availability

Novel starter strains for cheese flavour

Daniel Cavanagh, Teagasc Walsh Fellow.
Dr Olivia McAuliffe, Senior Research Officer, and **Dr Kieran Kilcawley**, Principal Research Officer, Department of Food Biosciences Teagasc Food Research Centre Moorepark, Fermoy, Co Cork.
Professor Gerald Fitzgerald, Department of Microbiology, University College Cork, Cork.
Correspondence: olivia.mcauliffe@teagasc.ie

Lactic acid bacteria, isolated from outside the dairy environment, possess different metabolic capabilities to their dairy counterparts, which may be exploited in the production of fermented products. Daniel Cavanagh received the Institute of Food Science and Technology of Ireland medal for his presentation on this topic at the annual Teagasc Walsh Fellowships seminar.

With the abolition of milk quotas in 2015, it is expected that cheese production in Ireland will increase significantly. An increased amount of cheese available on the market is expected to coincide with an increased consumer demand for more diverse flavoured cheeses. New starter culture systems, delivering specific flavour profiles, need to be developed to meet evolving consumer needs. *Lactococcus lactis* is an organism used extensively in the production of cheese. Strains of *L. lactis* from the wider, non-dairy environment are more metabolically diverse than their dairy counterparts. The flavour profile generated, by the addition of such strains to culture blends for cheese-making, may be targeted towards consumers of artisan or continental-type cheeses.

Isolation of non-dairy *Lactococcus lactis*

Eight *Lactococcus* strains were isolated from vegetable samples and grass and bovine rumen samples, collected at the Teagasc Animal and Grassland Research and Innovation Centre, Moorepark. Strain identity was confirmed using 16S rRNA analysis and subspecies identified by PCR-based methods. Multi-locus sequencing typing, based on seven genes, clustered all non-dairy strains away from dairy, highlighting the genetic diversity between strains of the same species but from different environments. Phenotypically, non-dairy isolates possessed an increased capacity to utilise different sugars compared to dairy cultures. All non-dairy isolates tested exhibited proteolytic activity.

Phage insensitivity and isolation of ΦL47

Bacteriophages are viruses that infect bacteria and are a considerable source of economic loss in the dairy industry. If strains isolated from outside the dairy environment are to be used in food processing it is important to understand their sensitivity to phage infection and the type of phages capable of infecting them. Non-dairy *Lactococcus* isolates were found to be resistant to a collection of dairy lactococcal bacteriophages. In the interest of furthering our knowledge of lactococcal bacteriophage diversity, we set out to isolate phage against *L. lactis* DPC6860, isolated from grass. Following repeated enrichments of raw sewage water, ΦL47 was isolated. Genome sequence analysis revealed this phage to be the largest sequenced lactococcal bacteriophage with a double-stranded DNA genome of 128,546 bp containing eight tRNA genes. Uniquely, this phage was found to possess a long tail fiber of 280nm, not previously found in lactococcal phages, which may be important in host recognition and adsorption.

Flavour diversification in mini cheeses

To ascertain whether non-dairy isolates could alter the flavour profile of cheeses, strains were selected for use as adjunct cultures in the production of mini Gouda-type cheeses by the production of volatile compounds in milk. The effect of a particular adjunct on proteolysis during ripening was strain-specific with DPC6855 showing the greatest contribution to proteolysis of all the non-dairy strains tested. Cheeses made with DPC6853 were more associated with a nutty flavour, off-aroma and off-flavours as determined by sensory analysis. The use of attenuated DPC6853 cultures positively enhanced the flavour profile of cheeses made using this adjunct, reducing its association with bitterness.

Concluding remarks

- Non-dairy lactococci possess different metabolic characteristics to dairy cultures, particularly in their sensitivity to infection by dairy lactococcal phages.
- The wider environment may be a rich source of lactococcal phage and could provide further insight into the bacteriophage diversity of lactococci.
- The use of non-dairy strains as adjuncts did not significantly alter cheese composition and contributed to the diversification of flavour profile in mini Gouda-type cheeses.
- This study highlights the potential of non-dairy lactococci for use in the production of fermented dairy products.

This work was supported by the Teagasc Walsh Fellowship Programme and the Irish Dairy Levy Research Trust.

Pictured at the Science Foundation Ireland Smart Futures roadshow as part of Science Week are: Graham Burns, CPL; Dr Rita Hickey, Teagasc; and Leo Dillon, SAP..

Science Week 2013

During Science Week, Teagasc research centres invite local schools to meet its research staff and learn about the work Teagasc does to support science-based innovation in the agri-food sector and the broader bioeconomy that will underpin profitability, competitiveness and sustainability.

Dr Des Walsh, Teagasc Ashtown, with students from Loreto Balbriggan viewing some bacteria under the microscope.

Science Week aims to promote the relevance of science, technology, engineering and maths in our everyday lives and to demonstrate their importance to the future development of Irish society and to the economy. Science Week is a Discover Science & Engineering (DSE) project. DSE initiatives are managed by Science Foundation Ireland on behalf of the Office of Science, Technology and Innovation at the Department of Jobs, Enterprise and Innovation.

Over 1,000 students attended Teagasc Science Week events in November last. "We are delighted to support Discover Science & Engineering's (DSE) Science Week initiative, which aims to promote the relevance of science, technology, engineering and maths in our everyday lives and to demonstrate their importance to the future development of Irish society and to the economy," said Dr Frank O'Mara, Director of Research at Teagasc.

In Athenry, students from local schools undertook a series of practical experiments to see how science is being used to address issues related to reproduction and parasitism in sheep.

At Teagasc Grange research campus, a demonstration of the beef and animal bioscience research was given. While at Teagasc Johnstown Castle, students learned about current Teagasc research in the areas of ecology, carbon cycling, water quality and soils, nutrient efficiency and sustainability.

At Teagasc Ashtown Food Research Centre, the aim of the fun-filled day was to promote an interest both in careers in scientific research, and the science behind your food – through demonstrations, presentations and interaction with researchers in food and horticulture. At Teagasc Oak Park, students got a tour of the biotechnology laboratories and to see part of the plant science and potato breeding programmes.

Agricultural Science pupils Ciara Burke and Daniel Keane from Athenry Vocational College at Teagasc Athenry for Science Week.

Researchers and technologists demonstrated the research programme and gave an insight into work at the forefront of crop science. In addition, Teagasc Oak Park's Dr Stephen Kildea talked at Carlow library on various well-known crops and their development and crop diseases.

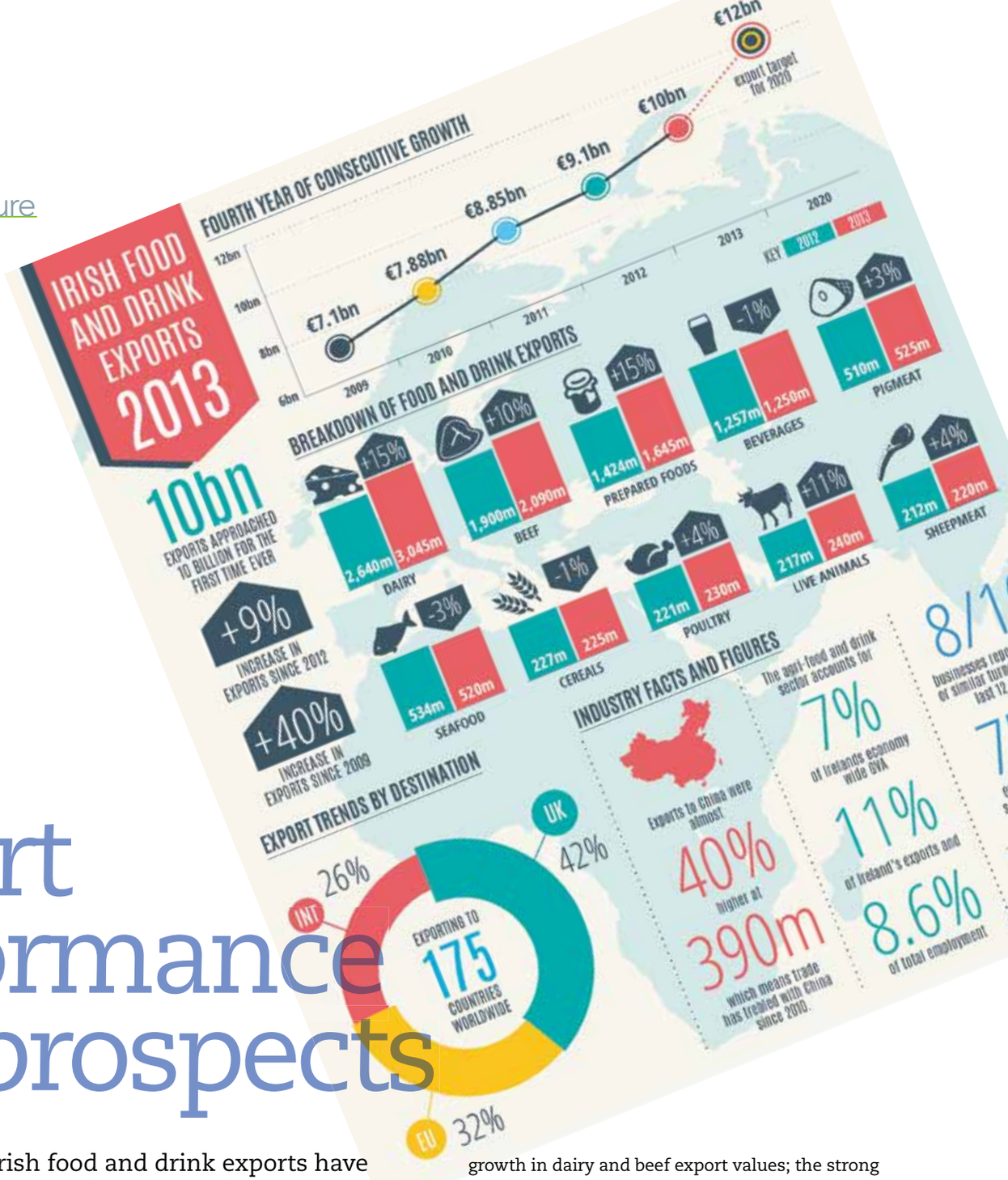
STEM career roadshow

Teagasc researchers also took part in DSE's 'Smart Futures' STEM (Science Technology Engineering and Maths) career roadshow with Dr Sinead Waters from the Animal and Bioscience Research Department, Teagasc, Grange speaking at Sligo Institute of Technology and Dr Rita Hickey, Teagasc, Moorepark speaking at the University of Limerick. Sinead currently leads a research programme that investigates the molecular mechanisms controlling economically important production traits, particularly muscle growth and development, feed efficiency and fertility in cattle. Rita is leading a research programme that investigates the biological properties of oligosaccharides isolated from food sources. In particular, she explores approaches to extract, identify and validate physiologically active oligosaccharides for use as ingredients in functional foods. Areas of current interest include biologically active oligosaccharides from milk that can aid in preventing infection and improve immune function.

Facebook competition

To celebrate Science Week, Teagasc gave away copies of The Science Squad Series 2 DVD (which features Teagasc Researchers and can be viewed on the TeagascMedia YouTube channel) courtesy of New Decade Television and Film.

Pictured at Teagasc Moorepark during Science Week are Colaiste An Chraoibhin, Fermoy students, Eoin Creagh and Michael Evans, with Christine Cummins, Teagasc Walsh Fellow.



Export performance and prospects

Irish food and drink exports have enjoyed four years of continuous growth, reaching almost €10 billion in value in 2013.

Irish food and drink exports were valued at almost €10 billion for the first time in 2013, according to new figures released by Bord Bia. This represents an increase of 9% on the previous year.

The strongest performing sectors were dairy, meat and livestock, and prepared foods.

Minister for Agriculture, Food and the Marine, Simon Coveney, said: "Export values of almost €10 billion are really impressive, and demonstrate the clear opportunity and benefit of investing in a sector with proven resilience, a significant domestic economic footprint and strong ability to grow. With increasing demand from more affluent consumers in key world markets, there is little doubt that the €12 billion export target set out in the industry-led strategy for the agri-food sector *Food Harvest 2020*, is well in sight."

Some of the highlights for 2013 include: double-digit growth in dairy and beef export values; the strong recovery in sales to eurozone destinations; and the strong performance of the industry in China, which is now Ireland's second-largest dairy and third-largest pork market.

Key markets

According to Bord Bia's Export Performance and Prospects 2014 report, the market distribution of Irish food and drink exports settled down during 2013 following the rise in the share of trade going to international markets over recent years. Currently, some 70%of Irish food and drink exports are to countries outside the eurozone.

The UK, however, remains the largest export destination for Irish food and drink with 42% of exports, worth an estimated €4.1 billion, reaching that market in 2013.

Exports to other EU markets increased by 11% in 2013, reaching €3.2 billion, with the key markets of Germany, France and the Netherlands all recording double-digit growth.

Strong exports to Asia, and, to a lesser extent, Russia

contributed positively toward an increase of 6% in the value of trade to international markets, which exceeded €2.6 billion in the period.

Exports to China grew by over 40%, with values trebling over the last three years to reach €390 million in 2013. It is now Ireland's sixth-largest market overall, driven in particular by strong dairy and pork exports. Seafood and beverage exports are also growing solidly, albeit from a lower base. Discussions are ongoing with Chinese authorities in relation to the opening of that market to Irish beef exports, which will further broaden the industry's presence in the world's fastest growing market. The Minister said opening the Chinese market was a huge priority for his Department and said Ireland was providing all the reassurances to China that it could to satisfy its requirements. He added that negotiations are also ongoing with the US to reopen that market to Irish beef exports. Furthermore, he said he was pleased with the progress of negotiations with Japan, which opened to Irish beef at the end of 2013.

Industry sentiment

A Bord Bia industry survey carried out among Irish food and drink manufacturers has revealed that exporters remain positive about prospects for their business. In total, more than 8 out of 10 reported higher or similar turnover in the last 12 months. Innovation remains important for many food and drink companies with 91% of exporters reporting that they had introduced new products in the last three years. Looking ahead to 2014, some 75% of exporters expect their export sales to grow.

Meat and livestock

It is estimated that the combined value of meat and livestock exports increased by 8% or almost €245 million to reach €3.3 billion in 2013. This leaves the sector accounting for one third of food and drink exports.

A combination of higher output in some categories, most notably beef and sheepmeat, together with stronger prices for cattle and pigs, helped boost the value of trade. The value of beef exports increased by almost 10% reflecting a rise of 5% in output and 4% in average prices. As a result, exports were valued at just under €2.1 billion. Despite a drop of around 2% in pigmeat production, a rise of almost 6% in prices helped to boost the value of Irish pigmeat exports by 3% to €525 million.

The competitive market environment for poultry persisted in 2013, although higher export volumes, combined with some improvement in prices led to the value of poultry exports rising by 4% to an estimated €230 million.

A rise of 7% in sheep output helped offset lower carcass weights and a marginal drop in prices to leave the value of Irish sheepmeat exports 4% higher at €220 million.

A jump of a third in cattle exports and a doubling in sheep shipments helped drive a rise of 11% in the value of livestock exports to an estimated €240 million.

According to the report the prospects for the meat and livestock sector in 2014 remain broadly positive with relatively tight supplies persisting across the EU for most species. While slow consumer demand is likely to continue, the overall trading environment is expected to be broadly positive, helped by strong global prices.

Dairy products and ingredients

Irish dairy exports reached an all-time high in 2013 with a value in excess of €3 billion. Strong global dairy prices and tight global supplies, combined with increased Irish availability as the year progressed, helped boost the value of dairy product and ingredients exports by an estimated 15%.

The strongest performing product categories were butter, cheese, infant formula, milk and cream, whole milk powder and whey.

Strong double-digit growth was evident across most European markets for Irish dairy products in 2013. In terms of international markets, significant increases to China and parts of South East Asia offset reduced exports to the US, Saudi Arabia and South Africa.

The prospects for Irish dairy exports in 2014 remain broadly positive with global demand likely to help clear any increase in output to keep prices well ahead of historical averages. Global stock levels and the relative strength of the euro will largely determine price prospects. Some further growth in Irish output is likely as producers prepare for the removal of quotas in 2015.

Commenting on Ireland's dairy sector, the Minister said the future was very exciting and he was encouraged to see a move, within the sector, away from commodity products to produce more added-value offerings that appeal to international market demands.

Prepared foods

Although trends varied in 2013, overall, exports of products covered under the prepared foods category increased by 15% to an estimated €1.65 billion. If value-added meats and poultry are included, exports were in excess of €2 billion.

The strongest performing categories during the year were fat-filled milk powders, which accounted for 80% of the export growth in the category, cooked meats, pizza, sauces, bakery and to a lesser extent confectionery. These helped to largely offset a slower trade in the frozen, ready-meal category.

While the UK continues to account for almost 40% of exports, ongoing diversification to markets across the rest of Europe and niche opportunities across international markets help to improve the market diversification of the sector.

According to the report, the strong focus by the sector on new product development, innovation and the identification of new customers means it is well positioned to identify and develop market opportunities as they emerge.

Edible horticulture and cereals

Stronger mushroom exports were offset by lower grain prices as the year progressed to put some pressure on the value of edible horticulture and cereal exports in 2013. Overall, exports of edible horticulture and cereals are estimated to have been marginally lower at €225 million.

Based on an article first published in *Irishfood* Edition 1 2014.

Innovative collaboration

A collaborative project between Teagasc and the Irish Dairy Board has developed new varieties of cheese. In 2013, the first of these was brought to market in Saudi Arabia.

In 2011, Teagasc and the Irish Dairy Board (IDB) announced the creation of a new Dairy Innovation Centre based in Moorepark, Co Cork. It was established to develop market-led product concepts that can be manufactured by IDB members, which would be then marketed internationally by the IDB.

"The Dairy Innovation Centre draws on the capability of the Teagasc Food Research Centre, Moorepark, to provide key scientific and technological advances, particularly in the areas of dairy chemistry and technology through its dedicated research staff and research programmes," says the centre's programme manager, Dr Diarmuid Sheehan. "This is combined with the IDB's ability to identify market opportunities, to harness consumer insights to drive innovation, and the IDB's considerable market and distribution infrastructure and global reach," he explains.

The first success of that collaboration was revealed in 2013 when the IDB announced that it was investing €20 million in its operations in Saudi Arabia to facilitate the production of a new cheese product for that market.

Saudi Arabian market

A fresh white cheese, called Labneh, is the first new product to emerge from the Teagasc/IDB collaboration. It is a white cheese variety that Professor Paul Ross, Head of Teagasc's Food Research Programme says has a huge market in Saudi Arabia. "It's a fresh cheese, originating from the Lebanon. It's commonly served on a bread or pizza."

To create Labneh, Teagasc and the IDB developed patented technology that allows innovative milk protein ingredients to be exported to the region and recombined at a local facility to create the fresh white cheese product.

The IDB's €20 million investment in Saudi Arabia includes the acquisition of a 75% interest in Al Wazeen Trading LLC (Al Wazeen) and the development of a new state-of-the-art cheese manufacturing plant at the Al Wazeen facility in Riyadh, which will be responsible for production of the final product.

Jeanne Kelly, Corporate Communications Manager, IDB says the IDB worked with its partners at Al Wazeen to trial the products in the region. She adds that the collaborative approach and on-the-ground experience of the company really helped to expedite the process. Furthermore, Jeanne says, the Irish product will benefit competitively in the Saudi Arabian market because it will be produced locally at an IDB facility in Riyadh.

Initially, the facility will supply dairy products to

Pictured at a recent visit to Riyadh are Professor Paul Ross, Head of Teagasc Food Research Programme, Teagasc, Moorepark; Kevin Lane, CEO, Irish Dairy Board; Mubarik Bajuwaiber, Chairman, AL-WISSAM ALARABI; and Minister Simon Coveney, TD, Minister for Agriculture, Food and the Marine.

the Saudi Arabian market. However, it is anticipated that IDB will use Saudi Arabia as a manufacturing hub for the Middle East and North Africa (MENA) region, supplying the Islamic Halal market segment. Saudi Arabia already imports more than 400,000 tonnes of dairy produce per year. Domestic milk self-sufficiency is relatively low, and milk production is under stress, due to the lack of water for crop growing as animal feed. Despite this, consumption of cheese and other dairy products is growing steadily throughout the region, offering an excellent platform for future growth for the IDB.

Routes to market

This investment is a key part in the IDB's strategy to grow routes to market and added value to Irish dairy produce in the run up to the abolition of milk quotas in 2015. It is expected the IDB will capitalise on its foothold in the region to introduce its existing range of products to market in the Middle East.

As Ireland prepares for the end of dairy quotas in 2015, the IDB believes the investment in the region will provide a key route to market for Ireland's excess dairy output.

Commenting on the announcement Kevin Lane, CEO, IDB said: "This announcement represents a major route to market and value for Irish dairy in the post-quota environment. This investment is strategically very important as it allows us to expand our business throughout the MENA region. Given that innovation and new product development are critical to growth, our partnership with Teagasc is an excellent example of how, with innovative technologies, we can create new ways of producing and selling dairy products for a global audience."

Future varieties

IDB plan to develop new cheese varieties in the future identified through the Teagasc partnership, IDB has plans to commercialise some of the varieties. "We will be launching a German cheese in the summertime," explains Jeanne. In addition to the IDB/Teagasc relationship, she adds that the IDB's internal R&D department has also been working on expanding its range of butter and cheese products for core markets in Germany, the UK and the US, as well as a new cheese product for the Russian and Chinese market. Diarmuid suggests: "The IDB-Teagasc partnership has significant potential to harness ongoing scientific research programmes at the Teagasc Food Research Centre Moorepark in areas including technology of continental and hybrid cheeses, structure-function relationships, as well as flavour chemistry and process and ripening optimisation for future success."

A shared agenda

Teagasc had been carrying out research into cheese diversification for five years, funded by the Department of Agriculture, Food and the Marine's Food Institutional Research Measure (FIRM) and Enterprise Ireland.

Professor Ross says Teagasc's research into the area of cheese diversification ties in well with the new product development agenda at the IDB; and its plans to maximise the expansion opportunities, which will be created for the Irish dairy sector when the EU abolishes milk quotas in 2015.

This partnership is a vital part of the IDB's strategy to increase the added value element of Irish dairy exports, and Teagasc's strategy to support innovative research by commercial Irish food companies.

"The IDB has an excellent network around the world selling Irish products. What was really attractive was that it could provide a real market pull for new products that we would develop."

Previous success

Teagasc has had previous success in the field of cheese development. The well-established Dubliner Cheese brand is an example of a successful new cheese variety developed by Moorepark researchers. Dubliner Cheese was developed as an alternative to cheddar cheese. However, the ambition was to create a cheese that could be manufactured using existing cheddar equipment, to eliminate the need for capital investment. It also has a unique flavour. The product was licensed and brought to market by Carbery in 1996. Teagasc followed this success with the launch of a probiotic-containing cheese by the IDB brand, Pilgrim's Choice.

Based on an article first published in *Irishfood* Edition 1 2014.

Genetics and disease resistance

Teagasc and TCD researchers are collaborating on a project to understand the genetics regulating the immune response to mastitis and uterine disease, and its potential for improving future cattle breeding strategies.

Bojan Stojkovic,
Teagasc Walsh Fellow.
Dr Kieran Meade,
Senior Animal Health Bioscientist, Teagasc Animal & Grassland Research and Innovation Centre, Grange, Co Meath.
Dr Rachel McLoughlin,
Assistant Professor in Immunology, Trinity College Dublin.
Correspondence:
kieran.meade@teagasc.ie

The high cost of infectious diseases

Mastitis and uterine disease represent massive economic constraints on the agricultural industry. In the context of anticipated dairy herd expansion, considerable effort has to be made to better understand the biological mechanisms involved in these diseases and to explore novel avenues to improve the response to both infection and therapy. Mastitis, a chronic infection of the mammary gland, often caused by *Escherichia Coli* and *Staphylococcus aureus* bacteria, leads to reduced milk yield, poorer milk quality, increased replacement costs and has negative consequences for animal welfare. A major concern for the dairy industry is the increase in the total concentration of cells in milk (referred to as the somatic cell count [SCC]), which results from infection. A single severe case of mastitis can cost up to €185 for veterinary treatment, labour and milk loss as a result of antibiotic treatment.

Uterine disease begins with the bacterial contamination of the uterus after calving, which persists in 25-40% of animals that develop clinical metritis, and this infection contributes to reduced fertility. Combined treatment costs and costs attributed to production losses were estimated at €292 per cow per pregnancy. With approximately 1.3 million cows in the Irish dairy herd and disease incidence ranging from 20-75%, we can calculate that uterine infection costs the Irish dairy industry between €76-€284 million annually.

Neutrophils in mastitis and uterine disease

The pivotal immune cell involved in defence during most infectious diseases – including both mastitis and uterine disease – is the neutrophil. Neutrophils are the most abundant immune cells and it is estimated that there is over 100 billion neutrophils circulating in a cow at any one time, ready to migrate toward, and eliminate, infectious agents. Neutrophils encapsulate bacteria and eliminate them by secreting potent enzymes and radical oxygen species. Additionally, microbicidal agents, including antimicrobial peptides, are secreted outside the cell to neutralise the pathogen.

During acute bacterial mastitis, neutrophils migrate from the blood to the mammary gland and can comprise over 80% of total cells found in milk. The success of the cow's immune defence against invading pathogens at the site of infection relies on the number and viability of these cells. With severe mastitis, the number of circulating neutrophils is decreased and their ability to produce microbicidal agents is significantly impaired, particularly during early lactation. An influx of neutrophils is also important for clearance of bacteria from the cow's uterus after calving. The ability of a cow to transition from a 'quiet' immune period during pregnancy to an 'active' period after calving can determine how successful this bacterial clearance is and whether uterine disease will result. Suboptimal neutrophil migration and impaired production of microbicidal enzymes are also associated with the occurrence of retained placenta, metritis and subclinical endometritis.

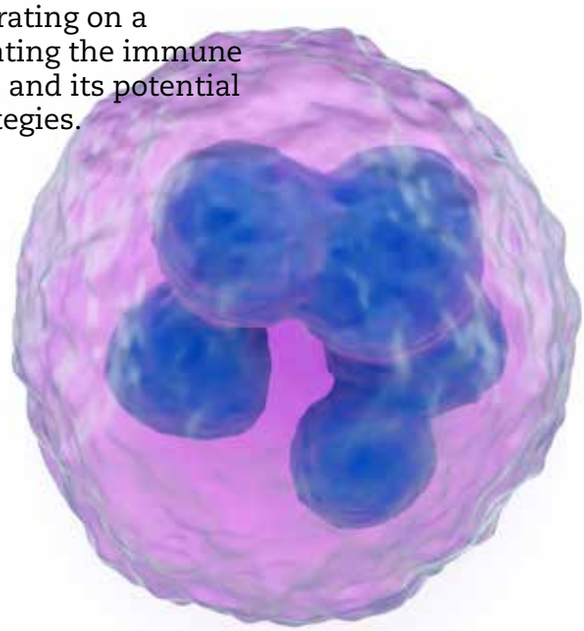


Image above shows a neutrophil immune cell with the characteristic multi-lobed nucleus.

Interleukin 8 – the master switch for neutrophils

The key molecule responsible for neutrophil recruitment and activation is interleukin 8 (IL8). It is a small protein, produced by most white blood cells (leukocytes), as well as the epithelial cells that line the uterus and mammary gland. IL8 is known as a chemokine, a group of proteins that attract leukocytes to the site of infection.

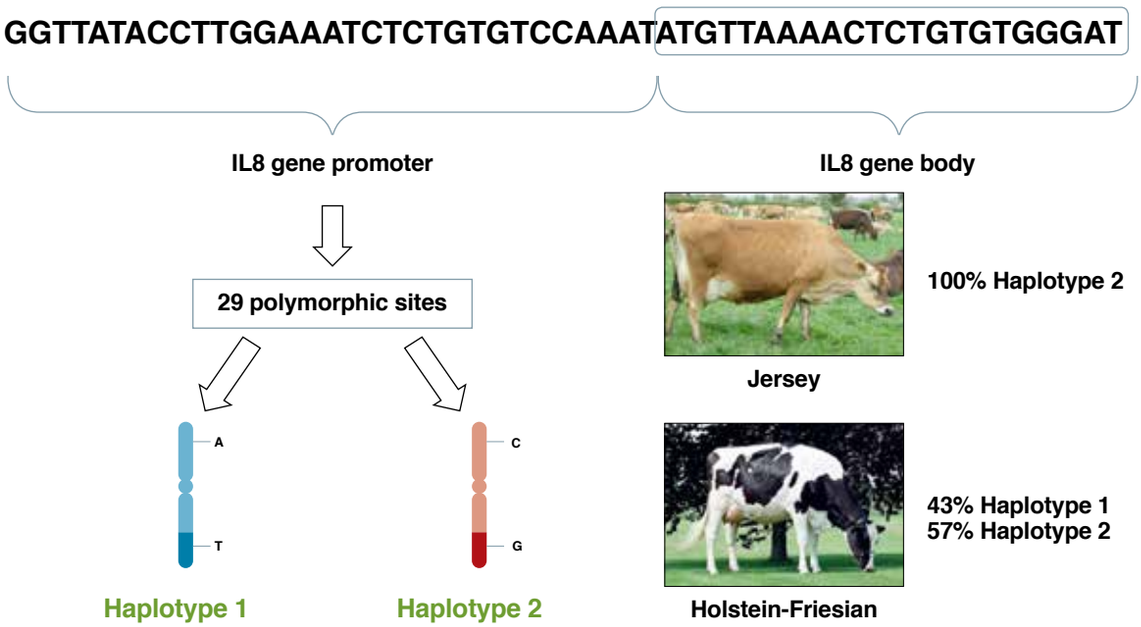


Figure 1. Analysis of the genetic structure of the bovine IL8 gene shows two distinct versions – referred to as haplotypes. While only 57% of Holstein-Friesians carry haplotype 2, 100% of Jersey cattle carry it, potentially contributing to differences in immune response between animals.

Once IL8 is in the blood circulation, it binds the receptor on the surface of neutrophils and triggers their recruitment and increased ability to produce antimicrobial agents.

A number of studies have demonstrated the vital role of IL8 in the immune response to both mastitis and uterine disease. Factors in milk from mastitic cows induce neutrophil migration and this ability is lost when IL8 is blocked, suggesting that IL8 is responsible for the massive influx of neutrophils that occurs during udder infection. The magnitude of IL8 upregulation has been shown to directly correlate with the concentration of bacterial *E. coli* in the mammary gland. In the uterus, the principal source of IL8 is endometrial epithelial cells. In the infected uterus, IL8 concentration is increased to help fight infection, but excessive influx of neutrophils can contribute to prolonged inflammation and tissue damage.

Bovine IL8 gene is highly variable in cattle

The first stage in the synthesis of the IL8 protein involves the activation of the IL8 gene. The most critical regions of the gene are the coding region – which contains the DNA that codes for the IL8 protein; and the promoter region – which contains the DNA that regulates the level of gene expressed, and, therefore, the amount of IL8 protein produced.

Research performed in Teagasc has identified a panel of 29 genetic variants (mutations) in the promoter region of the bovine IL8 gene (Meade *et al.*, 2012). Follow-on analysis has shown distinct differences between dairy breeds, which it is thought could contribute to the ability of some cattle to better fight infection (Figure 1). It is already known that genetic variation in this gene determines susceptibility to a number of infectious diseases, including tuberculosis, in humans. Studies in cattle have identified association between the IL8 gene variants and somatic cell score, as well as other milk traits. Teagasc functional work has also shown that the two major IL8 haplotypes are responsible for different IL8 gene expression profiles in bovine mammary and uterine epithelial cells, which are important coordinators of the immune response during mastitis and uterine disease, respectively.

Future directions in IL8 research

There is considerable variation in the ability of different animals to fight infection, and genetics plays an important role in determining the outcome of infection. Therefore, it is important that we study the neutrophil function in cows and calves with the two IL8 haplotypes, to identify potential differences in the ability of their neutrophils to migrate and kill bacteria. As neutrophils are short-lived cells that are easily activated, working with them is a challenging task, especially given the limited number of studies on bovine neutrophils. Applying what is already known from human and mouse studies to bovine research is an effective starting point, resulting from collaboration with the host-pathogen group led by Dr Rachel McLoughlin at the School of Biochemistry and Immunology in Trinity College Dublin.

Identifying the genetics regulating the ability of cattle to fight infection will help explain the variation we see in disease susceptibility and aid the design of better strategies to overcome disease challenges. Researchers are currently assessing the effects of IL8 genotype on the ability of calves to mount an immune response in the field. These 'real' experiments will determine the potential usefulness of this IL8 genetic marker to breed cattle with superior immunity in the future.

This research is funded by Science Foundation Ireland and the Teagasc Walsh Fellowship scheme.

Reference

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Automatic milking systems

A study is currently being conducted at Moorepark to determine the feasibility of integrating automatic milking with cow grazing.

Dr Bernadette O'Brien, Senior Research Officer,
Dr Cathriona Foley, Contract Research Officer,
Livestock Systems Research Department, Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co Cork.
Correspondence: bernadette.obrien@teagasc.ie

Dairy farming in Europe has adopted automatic milking (AM) at an accelerating rate, particularly in Western Europe (Jago, 2011). The main reasons for this are improvement in lifestyle, reducing physical work, difficulty in attracting skilled labour, increased profitability based on higher milk production (within high input systems) and lower labour costs. This trend is increasing and it is envisaged that up to 20% of cows in Europe will be milked automatically by 2020. However, while indoor feeding systems have been well adapted to AM, cow grazing systems have not. In order for AM to become a realistic alternative to conventional manual milking in Irish grass-based systems, the practical challenges of integrating AM and grazing must be researched. AM has the potential for advancement in precision dairy farming, e.g., to improve automatic data collection, providing herd managers with data that will enable them to make effective management decisions, and focus on strategic tasks that are economically beneficial.

Farm system description

A milk production system trial was put in place at Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, Co Cork. The dairy features one Merlin 225 AM unit (supplied by Fullwood for research) installed adjacent to the existing shed. The farm-let associated with the AM system consists of a 24ha milking platform. The system has 70 spring-calved cows of Friesian, Jersey-Friesian cross and Norwegian Red breeds.

The land area is divided into three grazing sections of 8ha each (A, B, C), which are further divided into 1ha paddocks. Four main roadways radiate from the centrally located dairy. Water is located at the dairy. The maximum distance to the furthest paddock is approximately 750m. The infrastructure incorporates a pre-milking waiting and post-milking area. There are three drafting units, two positioned at the entrance to the dairy that draft cows to the pre- or post-milking area depending on readiness for milking, and a third positioned at the dairy exit, which drafts cows to a holding yard or to grazing.

Grazing management

The grass allocation is critical to optimal cow visits to the AM unit (it can influence too frequent or infrequent cow visits). Cows graze defined areas or portions of each of the three grazing sections during each 24-hour period. Cows may be allocated, for example, 5kg DM in each of the three grazing sections (A, B and C) over each 24-hour period. Cows are moved between the grazing Sections A, B and C at 8am, 4pm and midnight, respectively. During the May/June period cows go into grazing areas with grass covers of 1,400-1,500kg DM/ha. Grass covers greater than 1,500kg DM/ha would discourage cow movement to the AM unit and may reduce milking frequency. Cows graze to a post-grazing height of 3.5-4.0cm. Cows are stocked at an average of 3.5 cows/ha. All cows receive approximately 1kg concentrate/day during the main grazing season.

Example of automatic milking unit.

Ongoing progress

An average milk yield of 4,222L and milk solids yield of 369kg per cow was achieved during the 2013 lactation. Even though 34% of the herd were 1st lactation cows, this level of milk production is still comparable with a large proportion of Irish dairy farms. Total milk volume and milk solids produced by the AM unit were 263,529L and 23,112kg, respectively. The average number of milkings per day was 104, ranging from 70 to 123 per day in the March-to-August period. The average number of milkings/cow per day was 1.8, ranging from 1.6 to 2.1. An average milk somatic cell count of 152,000 cells/mL was observed, while average total bacterial counts were at 10,000 cells/mL in the same time frame.

To optimise cow milking frequency

A main objective of this study is to investigate the effect of milking frequency on milk production characteristics and cow traffic. In a grass-based system, it is important to focus on the total output of the AM system rather than the output per cow. Thus, a trial was designed to answer the research question whether fewer cows with a relatively high milking frequency and milk yield, or a higher cow number accompanied by reduced milking frequency and lower per cow milk yield, resulted in a more profitable system. A preliminary trial was carried out in autumn 2013 (September 1-20). Cows were randomised into two groups of 35 cows each and two milking frequency treatments (approximately 1.5 and 2.0) applied to them. This was achieved by allowing cows to be milked if their predicted milk yield (at the time of the cow visit to the AM unit) was >50% and >33%, respectively, of their daily yield (averaged over the previous 10 days). Although these milking frequencies were significantly different (1.4 and 1.9 times per day), the milk yield per day (13.4 and 13.7kg/cow/day, respectively) was not significantly different between groups. This study now will be repeated over the complete lactation period in 2014.

Next steps in AM research

The practical challenges to integrating AM and cow grazing include: initiating cow movement to visit the AM unit; queuing of cows for milking; achieving high utilisation of the AM unit; and managing a seasonal calving pattern involving a peak milk yield period. The grass allocation was critical to optimal cow visits to the AM unit. Overall, the integrated AM and grazing system operated satisfactorily, but significant further research is required.

The economic viability of AM will determine how widely the technology will be adopted. A major challenge with automatic milking currently is the high capital cost but the concept of combining automatic milking and cow grazing has potential advantages, which could have a positive impact on the dairy industry in Ireland in the long term. These include: reduced labour input; management tasks as opposed to manual labour; ability to expand cow numbers on fragmented land bases; and increased knowledge of cow performance data to use as a management tool. However, considerable research needs to be conducted to establish if the concept presents a realistic alternative to conventional milking systems on dairy farms.

The fact that cow grazing systems have not been well adapted to AM has led to a decrease in grazing on farms with AM across Europe (Van den Pol-van Dasselaar *et al.*, 2011). This is an undesirable trend, since grass-based systems of animal production are becoming increasingly competitive. Allied to this is the positive impact on milk quality and reduced environmental footprint associated with increased quantities of grazed grass in the diet, as well as increased animal welfare standards.

Thus, the desire to research the integration of AM and cow grazing both in Ireland and other EU countries has led to a current three-year FP7 funded EU project (coordinated by Ireland) (AUTOGRASSMILK), which commenced in January, 2013 (http://www.autograssmilk.eu). Planned outputs include: protocols for optimum feeding strategies; pasture management tools; sustainability assessment tool; and a web-based decision support tool to optimise economic efficiency of AM in grazing scenarios.

This research has received funding from the European Union's Seventh Framework Programme.

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Dr Gary Lanigan, Research Officer, Teagasc, Crops, Environment and Land Use Research Programme, Johnstown Castle, Co Wexford.
Dr Thia Hennessy, Head of Agricultural Economics and Farm Surveys Department, Rural Economy Development Programme, Teagasc.
John Spink, Head of Crop Science Department, Teagasc, Oak Park, Carlow.
Stuart Green, Research Officer, Agri-business and Spatial Analysis, Rural Environment Development Programme, Teagasc, Ashtown.
Dr Owen Fenton, Research Officer Teagasc, Crops, Environment and Land Use Research Programme, Johnstown Castle, Co Wexford.
Dr Siobhan Kavanagh, Nutrition Specialist, Teagasc, Kildalton College, Co Kilkenny.
James O'Loughlin, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co Cork.
Dr Michael O'Donovan, Head of Grassland Science, Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co Cork.

Future weather – future farming

Following last year's fodder crisis, due to weather events, Teagasc recently held a conference to discuss the impacts of the previous winter's crisis and map out solutions for the future.

Irish livestock production is pasture-based and grass growth is a key factor, both in terms of the production potential and profitability of the livestock sector. This means that the production potential of Irish agricultural systems and weather are inextricably linked. Increased weather volatility resulting from climate change may pose serious challenges for Irish agriculture. This was exemplified by the fodder crisis during the winter and spring of 2012-2013, which resulted in significant losses to Irish agriculture. This highlighted the need for better systems to monitor grass growth at a national and farm level; and the need for extreme-weather events weather-based decision support and risk management in the sector. Ultimately, there is a need to generate adaptation strategies for, and to build weather resilience into, our production systems.

Impacts of the 2012-2013 fodder crisis

Teagasc economist, Dr Thia Hennessy outlined the financial impact of the 2012/2013 fodder crisis. The presentation included data on the additional expenditure, across the two years, on purchased concentrate feed, purchased fodder and fodder production, as well as losses in output. Expenditure on additional feed totalled approximately €400 million, while output losses were estimated at €65 million. However, it was noted that it was more difficult to quantify the negative impact of the crisis on product quality and the more long-term adverse productivity impacts, such as loss of animal condition, damage to soil and so forth.

Reducing the impact of weather volatility

Managing fodder stocks

Dealing with fodder deficits and the future prevention of deficits were detailed by Siobhan Kavanagh. She described how the prevention of forage deficits depended on adequate forage reserves, particularly on farms with heavy soils, in order to ensure the system is sustainable in challenging conditions. Whole farm feed budgeting is important to reduce the reliance on imported feed and exposure to volatile feeds market. It is important that farmers match the stocking rate on the farm to the grass-growing capacity of the farm. This is particularly important in the context of expansion in the dairy sector. Soil fertility, a planned fertilizer and reseeding programme are key to maximising forage production and reducing the risk of a fodder shortage. The implementation of an early warning system is required to reduce the risk of a fodder crisis recurring.

Drainage implementation and management

A third of milk produced in Ireland originates from farms where the soils can be classified as heavy; and grass production on these soils during the 2012-2013 winter/spring period decreased by almost a third relative to 2011. Teagasc initiated a heavy soils programme in 2009 to investigate the challenges facing farmers on heavy soils. James O'Loughlin (Teagasc Moorepark) and Dr Owen Fenton (Teagasc Johnstown Castle) detailed management solutions for optimising production on heavy soils. The main point, with respect to land drainage design in Ireland, is that there is no 'one-size-fits-all' solution. Instead, excavation of soil test pits to find where permeable and/or impermeable layers exist will allow a site-specific drainage design to be implemented. Groundwater systems should be installed in, or at least on, the upper part of the permeable layer at a spacing of ≥15m (€3,700-€6,200/ha) to effectively control the position of the watertable. Where no permeable layers exist, shallow drainage systems (e.g., mole (€125/ha) or gravel moles (€1,480/ha)) should be used. Maintenance of open drains will extend the lifetime of these systems. Increased productivity on heavy soils requires clear management decisions that mitigate the risks in farming such land. The capacity to grow adequate quantities of grass in a three-year cycle is dependent on high utilisation of productive perennial ryegrass swards and the provision of adequate silage reserves (at least 0.5t DM/cow).

Submerged winter wheat fields at Oak Park, Carlow, during February 2014.

Stocking rates must be matched to the grass growth and utilisation capacity of the farm. Based on potential grass growth of 12.5t/ha DM with all winter feed requirement conserved within the farm (including reserve), the optimum stocking rate is 2 LU/ha on heavy soils.

Monitoring grass growth

The impact of the fodder crisis highlighted the need for a grass-growth decision support system for farmers. PastureBase Ireland (PBI) is a database enabling the collection of regional grassland data across dairy, beef and sheep farms, while providing decision support information for farmers and collating the background research information into a centralised grassland database. This database stores all grassland measurements in a common structure, allowing the quantification of grass growth and dry matter production across different enterprises, grassland management systems, regions and soil types, using a common measurement protocol and methodology. Grass measurements are recorded on a regular basis and reports (grass wedge, distribution of growth and paddock summary reports) are automatically generated for management purposes. The reports allow individual farms to be benchmarked against other farmers in a discussion group, or to be benchmarked against farmers regionally. All farms on PBI are attached to their nearest Met Éireann weather station, which will allow the linkage between meteorological information to grass growth to be created.

The use of satellite imagery may also be used to monitor grass growth and can be particularly useful in teasing out long-term trends in vegetation growth and phenology (see *TResearch* winter 2013 issue, p34). The Spatial Analysis laboratory in Teagasc is currently using satellite imagery (particularly Near Infra-Red imagery) to generate vegetation indices that can be matched with grass-yield data from PBI in order to create predictive grass growth models. These models are currently in early development, but initial modelled biomass measurements for Teagasc Moorepark Animal & Grassland Research and Innovation Centre are matching well to field measurements. In the next two years, this model will be refined to produce reliable, parcel-scale estimates of standing biomass.

Tillage

Shifts in seasonal growth patterns, caused by climate change and/or increased incidences of drought and waterlogging, will also impact crop production. In contrast to grass grown for grazing or silage, tillage crops go through a defined series of developmental phases and certain phases impact yield more than others, depending on the crop. Winter wheat, for instance, generally produces sufficient grains in Irish conditions, but yield is sensitive to poor growing conditions or drought during grain filling. Barley yield, on the other hand, is less sensitive to growth conditions during grain filling but tends to be sensitive to conditions during the grain number formation period, i.e., early season. Therefore, growing a mix of crops reduces the risk of poor growing conditions in one particular part of the season resulting in a big reduction in production.

Quantifying future risks

In order to better quantify the risks and/or benefits of future climate change and any increases in weather volatility, Teagasc is funding a cluster of Walsh Fellowships to investigate the effect of future climate change and weather volatility Irish agriculture. The projects will assess the impacts on grass and crop productivity and carbon/nitrogen cycling across Ireland, measure the impact of extent and speed of drought on sward performance and ecosystem functioning, risk-assess the impacts of future volatility on current pollution abatement options and generate a list of future adaptation options. The project will ultimately produce a national climate risk assessment and will also identify region-specific risks and/or opportunities based on future local weather conditions combined with regional soil, topographic and land-use data, allowing tailored regionalised adaptation strategies to be developed.

Modelling pests in a changing climate

Teagasc and NUIM researchers are modelling the impacts of climate change on the grain aphid (*Sitobion avenae*) in spring barley: A simulation approach for Ireland.

Catriona Duffy, Teagasc Walsh Fellow, Irish Climate Analysis Research Unit, National University of Ireland, Maynooth.
Reamonn Fealy, Senior Researcher, AFBSA, Rural Economy Development Programme, Teagasc.
Rowan Fealy, Lecturer, Department of Geography, National University of Ireland, Maynooth.
Correspondence: catriona.duffy.2009@nuim.ie

It will come as no surprise that people within the agricultural community are very concerned about aphids. Yield reductions in spring barley of 11% and 20% have been reported as a result of their mechanical feeding and transmission of Barley Yellow Dwarf Virus (BYDV) respectively, while every year almost €50-60 million is spent on Plant Protection Products (PPPs). Every season heralds a different profile of these insect pests in a range of cereal and horticultural crops, and our best line of defence, thus far, has been of a chemical nature. However, the arena within which the seasonal battle between growers and aphids takes place is changing. With the relatively recent changes in EU legislation pertaining to PPPs and the transposition of the sustainable use of pesticides directive (SUD) into Irish law in 2012 (Directive 2009/128/EC); the manner in which pests are controlled is being revised. Further confounding the changing landscape of aphid control is the potential for pyrethroid (insecticide) resistance following the emergence of the Knock Down Resistance (kdr) gene in grain aphid samples in the UK (which confers resistance to up to 40 times the standard dose of pyrethroids). Our changing climate serves as the final piece in a trifecta of pest control challenges, which must be addressed in order to ensure future management strategies that are both ecologically sound and economically viable.

Aphid simulation model

The collaborative work between Teagasc and NUI Maynooth is addressing these issues in relation to cereal production by use of an aphid simulation model. The model has been designed to utilise an array of biological data garnered from laboratory studies to simulate the potential population dynamics of the grain aphid *(Sitobion avenae)* in Irish cereal crops in response to temperature. The work takes advantage of the well-established fact that temperature directly impacts the rate of development in insects and, as a result, the timing of important biological events (phenology) in relation to growers. By quantifying how temperature affects development in S. *avenae*, attempts can be made to assess the extent to which phenological events and population profiles will change in response to future projected temperature regimes.

Overwintering and emergence dates

An example of this relationship and how it can be used in forecasting systems, is the inverse relationship that exists between mean winter temperatures and the date on which the first winged aphid of this species is caught. Cold, severe winters result in a much later appearance of winged aphids in-field; while mild, warm winter temperatures facilitate earlier detection of the first catch. This finding is not entirely unexpected, considering that S. *avenae* is known to predominantly overwinter in an 'active state' (as opposed to producing a 'cold-hardy' egg) in UK regions where winters are not typically severe (South of Scotland). This strategy means that, during mild winters, active forms of this species can continue development and reproduction while the temperature is suitably high, but would be killed off by extremely low winter temperatures. Limited evidence suggests that this mechanism is similar in Ireland. Aphid monitoring from an unsprayed cereal stand in Teagasc Oak Park (Co Carlow) following the severe winter of 09/10 indicated virtually no aphid activity up to the end of April that year. For these reasons, the model discussed here assumes that the biology of this species is comparable in Ireland (latitudes south of 54° north in Western Europe), which facilitates the use of this relationship to model the beginning of spring migration into cereal crops.

Aphid and crop development

As part of this research, a model was developed to simulate the timing of first catch and potential dynamics of S. *avenae* in spring barley, based on the established relationship between temperature and phenology of the aphid. Synchrony between aphid and crop development is also considered in the model, through a simplified crop growth stage (GS) model. The simulation model (Figure 1) quantifies the stage-specific (age-specific) temperature-dependent development in S. *avenae* juveniles, from the onset of development following reproduction of the immigrating adults. Development (derived from empirical data) is calculated on a daily basis from the first nymph; to the point at which the aphid becomes reproductively active. The new adults subsequently produce nymphs at a rate determined

Aphid infestation, Oak Park, Co Carlow.

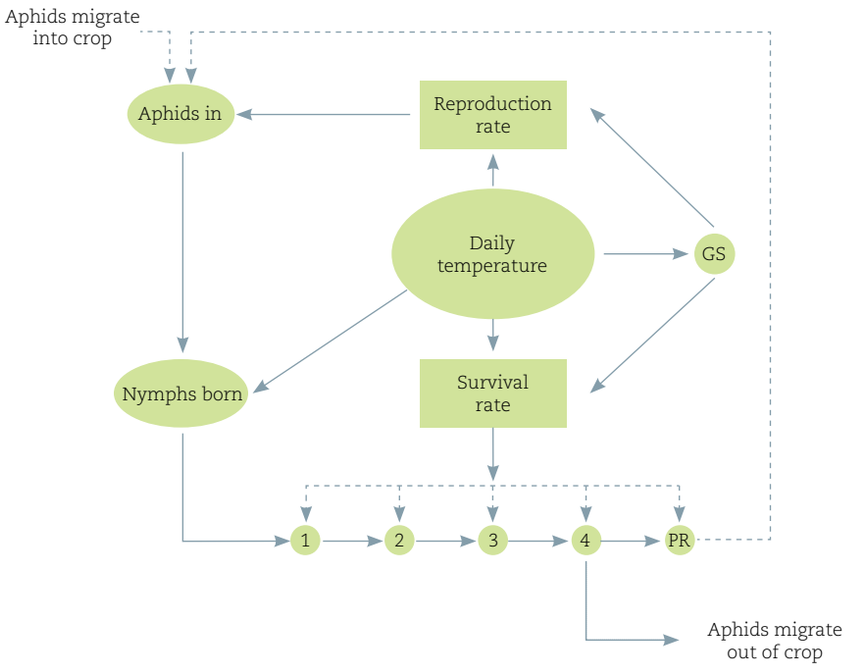

Figure 1. A simplified process diagram describing the simulation model for S. *avenae* (1=first developmental stage (ds), 2=second ds, 3=third ds, 4=fourth ds, PR=pre-reproductive phase, GS= Crop growth stage).

by the temperature experienced and the specific GS of the crop. The population eventually peaks once the total modelled number of aphids has surpassed both density and GS thresholds; and an increasing proportion of winged individuals are produced (who emigrate upon maturity).

Climate change risk assessment

The derived simulation model can be applied in real-time, for weekly to seasonal forecasting; or on a long-term basis using modelled future temperature data for Ireland. Preliminary results from the latter application indicate that there is a general trend towards earlier appearance of migratory aphids as the century progresses, due to increasing temperatures as a consequence of anthropogenic climate change. The impact of earlier aphid migration into crops will of course depend on the growth stage (GS) that the crop is at, as well as the date of sowing. In the case of long-term projections, these factors could serve to alter the interactions that take place between the immigrating aphids and their host plants. The current model provides an environment, through which interactions such as these and their outcomes, can be investigated.

Decision-support tool

The results referred to above are just the starting point for the model being developed in NUIM, which is ultimately aimed towards acting as a decision support tool for long-term management policy in relation to climate change and crop production in Ireland. This is particularly timely, as the publication of the National Action Plan (NAP) for the sustainable use of pesticides last year outlined intentions for specific focus to be placed on the area of Integrated Pest Management (IPM) and the promotion of its methods. In relation to harmful pest organisms, recommendations for monitoring pest populations as a tool for early-forecasting systems and decision-making regarding the application of chemical controls, is central to the IPM approach, while also explicitly stated as a SUD requirement. The type of model described here is consistent with the recommendations within the NAP; however, ongoing observations in-field are critical to this approach and this research has highlighted a significant knowledge gap in the Irish context. Any modelling attempts to provide 'early-warning' systems within a season or, indeed, long-term projections to contribute to the formulation of future adaptation strategies, will require data relating to the species biology and phenology if such models are to be viable. A UK-led network of aphid suction traps – which began in 1965 – now spans 19 European countries and provides the 'gold-standard' of long-term collaborative data-collection (Harrington, 2014). Considering the aforementioned changes to pesticide legislation, Ireland should now consider linking up with this network to facilitate enhanced monitoring of pest responses to environmental change.

Knowledge-based control strategies

The adoption of more 'knowledge-based' control strategies has the potential to benefit the agricultural sector in the future via the optimisation of prophylactic measures utilised by farmers, while simultaneously reducing costs on-farm. The *Food Harvest 2020* vision for agri-food in Ireland states that the industry needs to 'urgently prepare' for the impact of the new EU regulations outlined above. The model described here contributes towards bridging the gap between what we currently know about pests and how best to use that information in a changing climate.

Acknowlegments

GS data courtesy of Shane Kennedy, Teagasc Crops, Environment and Land Use Research Centre, Oak Park, Carlow.
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Fungicide resistance in head blight

Fungicide resistance in Fusarium head blight (*Microdochium nivale* and *Microdochium majus*) in cereal crops – expectantly similar but surprisingly different.

Dr Steven Kildea, Research Officer
Cliona Connolly, Contract Technician,
Teagasc, Crops, Environment and Land Use Research Programme, Oak Park, Carlow.
Correspondence: Stephen.Kildea@teagasc.ie

With perfect growing conditions during the summer of 2013 the difficulties experienced during the same period in 2012 are understandably easy to forget. As previously outlined by Spink *et al.* (2013) these difficulties ranged from the inability of crops to accumulate sufficient carbohydrates due to poor solar radiation, to the restrictions on yields due to the impact of fungal infections. While the production of cereal crops will always be at the mercy of the weather, certain protection measures can be taken. As fungal diseases often thrive under the Irish maritime climate, the most widely used measure to mitigate their impact is the timely application of fungicides.

Unfortunately, the ability of fungal pathogens to adapt to stresses – such as fungicides – through the development of resistance, can seriously impact the useful lifetime of an active ingredient. As Fusarium head blight (FHB) was identified as having significantly hampered yields in 2012, research was undertaken to investigate the fungicide sensitivity of those fungal pathogens responsible.

Fungal pathogens of cereal crops

Microdochium nivale and *Microdochium majus* are fungal pathogens that form part of the pathogen complex that causes Fusarium head blight on cereals (Figure 1). However, both pathogens also have the ability to hamper yields by reducing crop establishment through seedling blight. The most successful and, often, most reliable control method is the application of fungicides at planting in the form of seed treatments and at flowering as sprays. Unfortunately, the range of different fungicide modes of action with efficacy against *Microdochium* is limited. Principal among these have been the Quinone outside inhibitor fungicides (QoIs – commonly referred to the strobilurins), the benzimidazole fungicides (commonly referred to as the MBCs) and the triazole fungicide prothioconazole. Resistance to both the QoIs and MBCs has been reported elsewhere from the mid-2000s and early 1990s respectively. While the

Figure 1. Head blight on wheat and barley caused by either *Microdochium nivale* or *Microdochium majus*.

Figure 2. Frequency of resistance to the QoI fungicides as determined by the presence of the alteration G143A in *M. nivale* and *M. majus* isolated from wheat and barley collected in July 2012.

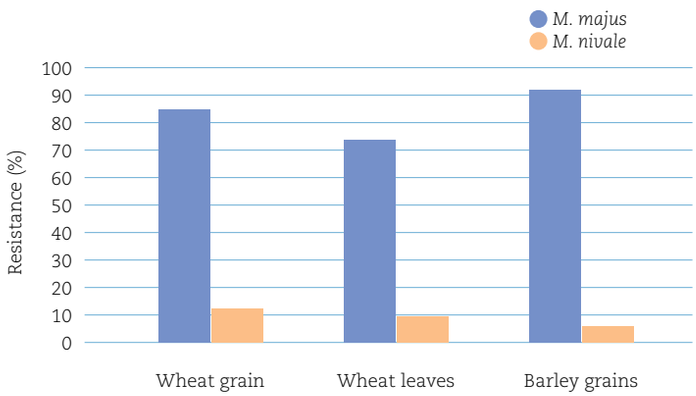

Figure 3. Frequency of resistance to the MBC fungicides as determined by the presence of the alteration E198A in *M. nivale* and *M. majus* isolated from wheat and barley collected in July 2012.

MBCs have not been routinely used for control on cereal crops for some years, the QoIs have been commonly recommended for FHB control. The high levels of infection in 2012 provided an abundance of samples from which the sensitivity to both fungicides could be established. Furthermore, since the mid-2000s both *M. nivale* and *M. majus* have been recognised as separate species; and 2012 also provided an opportunity to study the prevalence of each species in the different cereal crops.

Resistance to fungicides

In most cases where resistance has been detected, the ability of the pathogen to overcome the deleterious effects of the fungicides has resulted from one of three changes: alterations in the target site, which reduces the binding capacity of the fungicide; increased abundance of the target site through its over-expression; or pumping of the fungicide out of the pathogens cells and hence reducing the amount of chemical that actually reaches the target site. In the case of both the QoI and MBC fungicides, the most important means by which plant pathogens have developed resistance has been due to subtle changes in the target site. As the QoIs target fungal respiration the replacement of the amino acid glycine with alanine at position 143 (G143A) in the fungal cytochrome b allows the fungus to continue to respire even in the presence of extremely high levels of the fungicide. Similarly, the replacement of amino acid glutamic acid by various amino acids at position 198 (e.g. E198A) of β-tubulin, which is essential for fungal cell replication, renders the MBC fungicides ineffective.

Screening of samples

With the knowledge that the presence of such alterations will likely result in resistance to the fungicides, it is possible to screen large collections of the isolates in a relatively short period of time. In the case of QoI resistance, simple molecular assays based on PCR can be developed specifically to detect the change G143A. Due to the possibility that various amino acids can replace glutamic acid at position 198 in β-tubulin (leading to varying degrees of resistance to the MBCs), more detailed analysis – such as DNA sequencing – is required. Regardless of which method is employed, the techniques can be streamlined to ensure high throughput of samples.

In the collections of *M. nivale* and *M. majus* established from infected wheat and barley in July 2012, both species had exceptionally high levels of resistance to the QoIs fungicides (Figure 2). With resistance now dominating populations, the QoI fungicides are unlikely to provide control of *Microdochium* infections and this must be accounted for when fungicide programmes are being recommended.

Sensitivity of Irish populations

Although MBC resistance was detected in *Microdochium* in the UK and France as far back as the early 1990s, limited data has been available for the sensitivity of Irish populations. In the Irish collections screened after 2012, the alterations E198A and E198Q were detected. Subsequent phenotype screening of the impact of both alterations confirmed E198A conferred exceptionally high resistance; while E198Q conferred reduced sensitivity. As both pathogens (*M. nivale* and *M. majus*) appear at almost equal proportions on both wheat and barley grains, it comes somewhat as a surprise that resistance to the MBCs (defined as the presence of E198A) is almost nine times greater in *M. majus* than in *M. nivale*. Furthermore, the E198Q was only found in *M. majus*.

Still a role for MBCs?

Explaining these findings is difficult as the MBCs have not been applied to either wheat or barley on a wide scale for some time. It is possible that the alterations, which confer resistance (such as E198A) impose strong fitness penalties on *M. nivale* while imposing little or none on *M. majus*. Conversely it could be that sensitive strains of *M. nivale* have a fitness or selective advantage in the presence of other fungicides routinely applied to wheat and barley for the control of other diseases. While the implications of these findings still remain unclear in terms of controlling both pathogens on wheat and barley, as *M. nivale* is the dominant of the two pathogens on oats and in turf grass there may well be a continued role for the MBC fungicides in controlling these problematic pathogens.

This research is funded by the Teagasc core programme.

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Figure 1. Thinning assortments - a potential source of energy wood.

Forestry energy for dairy processing

The use of forest-based biomass can improve the overall energy efficiency of milk processing plants through the replacement of heavy fuel oil with indigenous biomass, reducing costs and creating more carbon-efficient products and may assist in the sustainable development of agriculture toward *Food Harvest 2020*.

Dr Niall Farrelly, Research Officer,Teagasc, Forestry Development Department, Athenry, Co Galway.
Dr Joanne Fitzgerald, Formerly Research Officer, Teagasc, Forestry Development Department, Oak Park, Co Carlow.
Henry Phillips, Forestry Industry Consultant, Cloot na Bare, Rathonoragh, Co Sligo.
Noel Kennedy, Forestry Development Officer, Teagasc, Forestry Development Department, Co Roscommon.
Correspondence: niall.farrelly@teagasc.ie

Forestry as a source of biomass

The potential for the private forestry sector to contribute significantly to *Food Harvest 2020* is a positive development for the forestry sector and the wider agri-bio-economy. Forests offer the potential for greenhouse gas emission reductions through accelerated carbon sequestration and fossil fuel substitution. This research goes someway to identifying the potential of farm forests to meeting the Renewable Energy Directive (2009/28/EC), which has set ambitious targets for Ireland – that by 2020 at least 16% of all energy consumed is from renewables.

While the private forest sector now accounts for 47% of the total forest area, a recent COFORD report on wood supply and demand (Phillips, 2011) indicates that the demand for indigenous-based wood products is set to increase to 6.04 million m^3 by 2020, including an estimated demand of 3.08 million m^3 for wood biomass for energy purposes; leaving a shortfall in supply of circa 1 million m^3 by 2020 and almost all of this in the forest-based biomass category. Therefore, any increase in future supply is dependent on privately-owned forests. If future forecasts are to meet the needs of industry, they must provide detailed estimates of wood energy and catchment-based potential supply volumes, bearing in mind the issues of accessibility and site productivity.

Teagasc research has succeeded in assessing the potential supply of energy wood from forest to a major heat user (Farrelly *et al.*, 2013). The 'Supplychip' project provides forecast estimates of energy wood assortments, based on realistic outputs from farm forest holdings, representing 5% of the private forest resource nationally, and will be an important decision-making tool for potential major users of renewable heat. Over 3,000 individual private plantations, clustered around Ballaghaderreen, Co Roscommon, were assessed for site productivity and road access and suitability for thinning.

Forecasting wood energy output

The research provided a methodology to generate local supply forecasts for wood energy for local producer groups or for a potential end user or group of end users. Local supply forecasts were based on extensive spatial analysis and quality control procedures, to assess the potential of the forest resource as a source of thinnings for wood energy, based on detailed forest forecasting and thinning rotation classification (Figure 2). The outputs from private forests were modelled using four possible wood energy scenarios in order to evaluate the potential supply to three possible end types (Table 1).

- Scenario S1: 40% of the 7-13cm assortment go to wood energy;
- Scenario S2: 40% of the 7-13cm and all tree tops (tip-6cm) go to wood energy;
- Scenario S3: 100% of the 7-13cm and all tree tops goes to wood energy; and
- Scenario S4: 100% of all size assortments go to wood energy.

User	Potential users	Demand	Likely scenario	Comments
Local level	Town-based facilities (nursing homes, etc.)	<20,000m^3	S1	Sufficient available wood energy under scenario for 10-20 local facilities
Medium scale	Ballaghaderreen dairy processing facility (12 MW steam boiler)	35,000-40,000m^3	S3	Only scenario three offers a realistic supply, likely will have to rely on additional sawmill residues with scenario two
Industrial scale	Lanesborough (co-firing)	100,000m^3	S4 S1-3 with increase of catchment area to 40,000ha	Only scenario four offers a realistic supply, would have to rely on additional volume assortments or increase catchment area

Table 1. Potential end-users and demand levels.

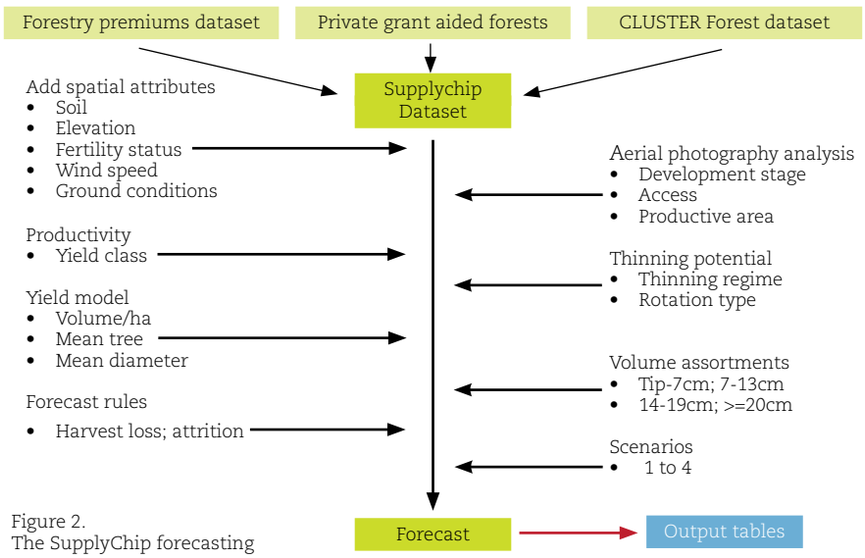

Figure 2.
The SupplyChip forecasting

Potential end-users

Scenario modelling suggests that, where only 40% of pulpwood is utilised as a wood energy assortment, there would be enough material to supply local wood energy markets. Under scenario S2, approximately 50% of the demand for a 12 MW boiler facility in the region could be met. Under scenario S3, there is more than sufficient volume to meet the demand associated with a 12 MW steam boiler (e.g., Aurivo milk processing plant, Ballaghaderreen).

The potential to supply larger co-firing facilities (e.g., Lanesborough power station) is limited, and the only scenario that offers any sort of scale of supply is S4, where all of the harvested material goes to energy wood.

Milk processing – increasing energy efficiency

The outputs of the research have coincided with the decision by Aurivo (formerly Connacht Gold) to invest €5.5 million in a state-of-the-art 12 MW steam boiler plant in its dairy ingredients plant in Ballaghaderreen. The steam boiler will allow Aurivo to further improve the overall site energy efficiency at Ballaghaderreen through the replacement of heavy fuel oil with indigenous biomass, the phased introduction of electrical generation through the move to CHP and the reduction in energy consumption of the core milk processing activity on the site. It also offers a significant marketing opportunity to have carbon neutral products to market to the increasingly conscious consumer.

Considering the range of competing markets for roundwood, the availability of biomass from the private sector will ultimately depend on the price attained for woody biomass. There could be enough material for up to 12 or more boilers and CHP plants of 15 MW capacity throughout Ireland. This development would contribute significantly to meeting renewable energy and emission reduction targets, with the added important benefits of stimulating thinning and management activity by local forest owners and reducing manufacturing costs, not least in the expanding competitive dairy-processing sector.

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Food labelling and allergen awareness

Ita White,
Food Industry Development, Teagasc.
Correspondence:
ita.white@teagasc.ie

Ita White, Food Industry Development, Teagasc, writes about how changes in EU food labelling legislation may impact on the food industry and the importance of allergen awareness.

Changes in consumer information requirements that will come into force in 2014 will have implications for packaging design for food businesses. Food producers will have to redesign their product information in order to comply with the new Food Information for Consumers Regulation (EU, 2011). For many this will mean new labelling and/or new packaging where consumer information is pre-printed on the packaging.

Some of the main changes of note include changes to the description of the food (to avoid misleading the consumer), how allergens must be declared, font size and format, origin or provenance of certain foods/ingredients and nutritional information. Most of the changes apply from December 13, 2014, with the requirement for compulsory nutritional labelling coming into force in December 2016 (unless there are claims made or voluntary information is given, in which case the earlier date applies). Further details are available from the Food Safety Authority of Ireland (FSAI, 2012).

Allergen labelling

One aspect of note is the topic of allergen labelling as this has implications for manufacturing and supply of raw materials, including packaging. There are 14 allergen categories listed in European legislation that must be labelled if included in the ingredients (Table 1-first column). There are a number of exemptions for highly refined products. The full list of allergens and exceptions are listed in Annex II of the Food Information for Consumers Regulation (EU, 2011). In addition to this, food producers will need to carry out a risk assessment for potential accidental contamination of allergens and determine if precautionary labelling may be warranted. Food producers will need to communicate with suppliers of all raw materials to check if any of these allergens may be present – even in small amounts.

Hidden allergens

One aspect to watch out for is 'hidden allergens', e.g., allergens that are not obvious as ingredients but may be compound ingredients, i.e., part of another ingredient, such as sesame seeds in tahini. Food businesses should also examine their manufacturing processes and those of their suppliers for any 'hidden allergens'. For example, are there any lubricants used for equipment maintenance that might be based on nut oils (e.g., peanut), or any releasing agents used on packaging that could contain allergens? Some packaging materials contain release agents that are wheat-based (containing gluten) and can transfer to the food product packaged inside. For example, a wheat-based release agent may be used to keep paperboard or foil from sticking together during processing. Businesses exporting to customers outside

ALLERGEN DATA				
Allergen	Requires labelling Yes/No?	Source	Present on line? Yes/No	Present on site? Yes/No
Cereals containing gluten	Yes	Wheat	Yes	Yes
Crustaceans and products thereof	No		No	No
Egg and products thereof	No		No	No
Fish and products thereof	No		No	No
Peanuts and products thereof	No		No	No
Soybeans and products thereof	No		Yes	Yes
Milk and products thereof (including lactose)	No		Yes	Yes
Nuts (other than peanuts) and products thereof	No		No	No
Celery and products thereof	No		No	No
Mustard and products thereof	No		No	No
Sesame Seeds and products thereof	No		No	No
Sulphur dioxide and sulphites	No		No	No
Lupin and products thereof	No		No	No
Molluscs and products thereof	No		No	No

Table 1. Example of good allergen data in a supplier specification.

of the EU should also familiarise themselves with the allergen rules in the market they are targeting, as requirements can vary depending on the population profile.

Risk analysis

Ideally, the approach to take would involve a risk analysis:

Firstly the risk of allergens being present should be assessed. This would involve identifying any allergens on-site by looking at the products produced, the processes, processing aids, etc. Map where these occur on-site to identify 'hot-spots' for contamination risk. Not forgetting the possible risk of allergens being present in ingredients or on packaging.

If allergens are used on-site the producer should review their good manufacturing practices (GMP) to ensure allergens are effectively managed and to see if risks can be reduced. Information and assurances provided by suppliers should also be reviewed. An important document in this regard is the product specification.

The final step is to communicate any residual risk to consumers via labelling or other product information, including electronic means such as websites.

Table 1 provides an example of how allergen information might be included in a product specification by a supplier. As you will see in the example, each of the 14 allergen categories are listed and there is an indication as to whether the allergens are included in the product or not, or if they are used on the same production line or on-site. There is also an indication as to whether the customer needs to label for the presence of these allergens or not. The decision as to whether this is necessary or not should be based on the results of the risk assessment. This type of approach would help food businesses determine if an allergen declaration is required or if precautionary labelling might be necessary.

Good manufacturing practice

Remember that GMP is vital to reducing the risk of a number of potential food safety hazards – including allergens – being present in food. Food producers should adopt a suitable standard or code of practice for GMP. Most, if not all, standards will require a formal hazard analysis/risk assessment to be carried out and appropriate control measures put in place. This may include allergen control measures such as segregating production either by location or time, strict controls on materials, equipment and personnel that may come in contact with allergens, cleaning regimes and limits around rework among other measures.

Another option for food producers is to have an exclusion policy, i.e., to exclude known food allergens from the site in order to provide assurances for customers. This may involve redesign of product or processes to remove allergens that have been identified. If this option is chosen then it is important when developing new products or introducing new materials on-site to include a check that allergens are not being introduced. Product development procedures need to include this allergen check and there should be a change notification procedure for suppliers.

The customer-supplier relationship is important for food safety assurance and good communication is crucial. Best practice in product development and supply chain management recommends that there should be a change notification procedure. Customers and suppliers should agree what changes/substitutions are permitted, if any, and how these should be notified. When introducing any new materials, products or processes, a food safety risk assessment should be performed, and allergens considered as part of this assessment.

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Milk sugars and human health

Teagasc researchers and their NUIG and UCD colleagues are investigating the health potential of sugars found in milk.

Dr Jonathan A. Lane, Research Officer, **Dr Mariarosaria Marotta,** Research Officer, **Dr Joseph Thomas Ryan,** Postdoctoral scientist, **Dr Rita M. Hickey,** Senior Research Officer, Department of Food Biosciences, Teagasc Food Research Centre, Moorepark. Correspondence: rita.hickey@teagasc.ie

Breast milk is considered the gold standard of infant nutrition as it contains the essential nutrients to support early infant growth. The components of mother's milk, in addition to providing nutrition, have been proposed to offer additional benefits such as stimulation of development and regulation of the neonatal digestive system, enhanced absorption of iron and calcium, stimulation and function of the immune system and promotion of the development of the brain and nervous system. Indeed, studies are now emerging that highlight the benefits of breast milk consumption for individuals later in life.

Research to date has mainly focused on the biological roles breast milk lipids, proteins and peptides play during the early stages of life. However, little research has focused on the role of the milk sugar/carbohydrate fraction. It has now emerged that oligosaccharides, which are composed of three to 10 monosaccharide residues, whether free or bound to lipids or proteins, play essential roles as communicative and protective molecules. Indeed, breast milk oligosaccharides have been proposed to: selectively stimulate the growth of beneficial microbiota; protect against bacterial and viral infection; promote the maturation of the infant immune system; and improve brain growth and development. The lack of commercial products on the market that contain breast milk carbohydrates is indicative of the fact that breast milk is not readily available in large quantities for the extraction of these bioactives. Therefore, there is a need to identify alternative sources of health-promoting carbohydrates for inclusion in functional foods such as infant formula. At the Teagasc Food Research Centre (TFRC), Moorepark, a team of researchers led by Dr Rita Hickey, are investigating cow's milk as a source of natural, health-promoting carbohydrates.

Cow's milk carbohydrate research

Since 2006, the research team at Moorepark has been working on technologies to isolate, enrich and structurally characterise cow's milk carbohydrates. Indeed, the team has successfully developed methodologies for enriching carbohydrates from cow's milk resulting in the production of kilogram quantities of oligosaccharide-enriched powders. Optimisation of technologies to produce milk oligosaccharides at industrial scale will continue as part of a long-term industry-academic collaboration, Food for Health Ireland (FHI). Within FHI, the team will build on existing capability and will demonstrate a clear ability

to transition the outputs of FHI to a commercialisation phase for the participating companies (Carbery Group, Dairygold Food Ingredients Ltd, Glanbia plc, Irish Dairy Board and Kerry Group plc).

The Teagasc group is also a partner of the Science Foundation Ireland (SFI)-funded Alimentary Glycoscience Research Cluster (AGRC) (www.agrc.ie), which is led by Professor Lokesh Joshi at the National University of Ireland, Galway (NUIG). As part of the AGRC, the Teagasc team has collaborated with Professor Pauline Rudd's group at the National Institute of Bioprocessing Research and Training (NIBRT) (www.nibrt.ie). This collaboration has resulted in the development of novel robust HPLC- and UPLC-based technologies for the complete structural characterisation of milk oligosaccharides (Marino *et al.*, 2011; Albrecht *et al.*, 2014). The application of these novel technologies, by Professor Rudd's group has led to many exciting scientific discoveries. For example, the structural characterisation of oligosaccharides-enriched powders, produced on-site at Moorepark, from a variety of animal milks (cow, goat, sheep, pig, horse, and dromedary camel), revealed the presence of several new free oligosaccharides that share a high degree of structural similarity to human milk oligosaccharides (Marino *et al.*, 2011; Albrecht *et al.*, 2014).

Novel health benefits of cow's milk carbohydrates

A major finding for the research team, was identifying cow's milk as a potential source of anti-infective oligosaccharides that may be capable of neutralising the threat of bacterial enteric and respiratory disease. Indeed, cow's milk oligosaccharides were shown to reduce *Campylobacter jejuni* and *Pseudomonas aeruginosa* invasion into human colonic epithelial cells and human pneumocytes, respectively (Lane *et al.*, 2012; Marotta *et al.*, 2014). Although it is necessary to perform *in vivo* human trials with these bioactives, these results suggest that they could have a major impact on human health once consumed. Another significant scientific discovery, made by the Teagasc group, in collaboration with Professor Joshi's group at NUIG, was demonstrating that milk oligosaccharides, which are known to selectively stimulate the growth of Bifidobacteria, an important infant colonising bacterial species, also promote their colonisation potential. Indeed, a dominant human and cow's milk oligosaccharide, 6'-sialyllactose, was shown to increase the adherence phenotype of *Bifidobacterium longum subsp. infantis* in a multi-faceted approach involving transcription factors, chaperone proteins, adhesion-related proteins, and a glycosidase hydrolase (Kavanaugh *et al.*, 2013). Promoting commensal colonisation during the early stage of life could have several beneficial outcomes for the infant, including resistance against pathogen colonisation.

Most of the examples, outlined above, refer to free milk oligosaccharides, however, as part of the expanding glyco-science research programme at Teagasc, the team (including Dr Joseph Thomas Ryan) in collaboration with Professor Joshi, are also researching strategies to isolate glycoproteins and glycopeptides from milk with beneficial properties. Very little is known about the glycans associated with milk glycoproteins, in particular, the extent of variation in glycosylation among species and at different stages of lactation; and how variation might affect the biological roles of these glycoproteins. Thus, the group at NUIG and Teagasc has begun to investigate the glycosylation profiles of key cow's milk glycoproteins, using innovative lectin array technology (O'Riordan *et al.*, 2014a), and to profile the activity of cow's milk glycosidases given that the glycosidic release of terminal sugars from glycoproteins affects their biological activity (O'Riordan *et al.*, 2014b).

Although there are structural similarities between human and cow's milk carbohydrates, there are also distinct differences. The biological significance of these differences remains unknown; however, the team at Moorepark has obtained valuable information that could give researchers an insight into the biological similarities and differences of human and bovine milk carbohydrates. This information was obtained by performing human gene expression analyses on human colonic epithelial cells exposed to human and bovine milk oligosaccharides. Interestingly, both treatments had potential effects on similar cellular processes (Lane *et al.*, 2013). Although there were distinct differences in the number and induction levels of genes after each treatment, overall this research highlighted the promise of cow's milk as a suitable source of carbohydrates for use in functional foods/infant formula that may function similarly to those found in human milk.

Acknowledgements

Dr Jonathan Lane presents an overview of the work carried out at TFRC, Moorepark in collaboration with NUIG, NIBRT and UCD. The authors would like to thank the funding agencies (Department of Agriculture, Food and the Marine, Science Foundation Ireland and Enterprise Ireland) and industry partners in Food for Health Ireland, Irish Dairy Board, Carbery Group, Dairygold Food Ingredients Ltd, Glanbia plc and Kerry Group plc. The authors would also like to acknowledge Dr Raj Mehra, formerly of Teagasc, who initiated research on milk oligosaccharides in Teagasc before his retirement in 2010; Helen Slattery; current Walsh fellows, Shane Feeney, Sarah Ross and Erinn Quinn; and former Walsh Fellows, Dr Devon Kavanaugh and Noelle O'Riordan.

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Potential of nanotechnology in agri-food

Dr Maeve Henchion, Head of Department, Agrifood, Business and Spatial Analysis, Rural Economy Development Programme, Teagasc.
Dr Moira Dean, Lecturer in Psychology of Consumer Behaviour, Queen's University Belfast.
Dr Katrina Campbell, Lecturer in Bioanalytical Systems, Institute for Global Food Security, Queen's University Belfast.
Correspondence: maeve.henchion@teagasc.ie

A workshop exploring the potential of nanotechnology in the agri-food industry recently took place and explored applications, opportunities and challenges in this new field of science.

Nanotechnology involves manipulating and changing material and systems on the nanoscale level (up to 100 µm). Working at this scale results in unique physicochemical properties that may differ greatly from those at the macroscale, e.g., nano products can be stronger, lighter and have greater chemical reactivity than their larger-scale counterparts. It is these enhanced properties that have resulted in nanotechnology emerging as a technological advancement that has the potential to contribute to solving many of the grand challenges (e.g., obesity and global warming) that currently affect the world. Some products based on nanotechnology are already available in the marketplace. However, it is not yet clear whether nanotechnology will reach its potential. This is for several reasons, including concerns about consumer acceptance, regulatory challenges and scientific uncertainty. A recent workshop, held at Teagasc Food Research Centre Ashtown, discussed the applications, opportunities and challenges of nanotechnology in the agri-food sector. The workshop, hosted by the Institute for Global Food Security, Queen's University Belfast (QUB) and Teagasc, and sponsored by *safe*food, was highly innovative in bringing together scientists from social science and physical science perspectives. Bringing these different perspectives together is very important as public attitudes and perceptions have been shown to influence (both positively and negatively) the direction and pace of scientific activity in a number of fields, e.g., GMO, biotechnology and functional foods.

Potential for agri-food sector

Dr Frans Kampers, coordinator of the bio-nanotechnology research programme at the Dutch agricultural research organization (DLO), Wageningen University and Research Centre, provided examples of nanotechnology applications for the agri-food sector. These included biosensors for sensing and diagnostics to monitor the quality and safety of foods or to diagnose food production problems; encapsulation of pesticides for targeted and on-time delivery of the agent; self-assembly systems for healthy ingredients; structuring of food stuffs, for instance to develop alternatives for meat from plant protein sources; and applications in food packaging to extend the shelf life of fresh products. Both Dr Olivia McAuliffe from Teagasc and Dr Katrina Campbell from QUB presented on aspects of their research on further applications in the use of nanomaterials as phage-derived nanomaterials. Dr McAuliffe focused on their subsequent applications in food and medicine while Dr Campbell discussed the use and possible directions of nanosensor development in food safety monitoring.

Consumer acceptance of emerging technologies

Consumer perspectives were initially broached by Professor Lynn Frewer, Newcastle University. She highlighted that consumer acceptance of emerging technologies needs to be understood early in product development to avoid some of the past experiences associated with genetically modified foods, for example. As well as risk (and benefit) associated with different applications, other issues (for example related to the ethical concerns of different stakeholders) need to be addressed when advancing commercial development of the technology and developing the associated regulation. This theme was further developed by Dr Mary McCarthy, University College Cork. She highlighted that acceptance of different technologies varies and is based on evaluations of their personal or societal benefits.

She stated that initial attitudes can be unstable and may change as additional information is provided. She concluded that needs satisfaction of targeted segments has to be a core consideration when planning the commercialisation of novel food technologies. Dr Maeve Henchion, Teagasc, presented findings from a recent survey that examined consumer acceptance of nanotechnology specifically. She concluded that public engagement about nanotechnology needs to stimulate interest in the technology and its potential applications, as well as promote awareness; acceptance of nanotechnology is strongly influenced by the application in question and the benefits offered; and consumer acceptance of food applications of nanotechnology varies; however, consumers can be grouped based on similar characteristics.

EU regulations

Dr Pat O'Mahony, Food Safety Authority of Ireland and scientific expert on the European Food Safety Authority Scientific Network for Risk Assessment of Nanotechnologies in Food and Feed, outlined the current status of EU regulations relating to food and food packaging consisting of, or containing, engineered nanomaterials. He also provided an insight into pending legislation with regard to labelling that will govern how consumers are made aware of the use of nanomaterials in food production. To date in the EU, there are very few foods openly declaring a content of engineered nanoparticles or their use in food production but he also acknowledges that the level of research and development by the food industry in this area is not immediately clear. Caroline Handford, from QUB, continued the theme of industry use of nanotechnology when she presented results of a survey examining industry's awareness and perceptions of nanotechnology. Her preliminary findings show that, although a limited awareness of nanotechnology exists, the uptake in the use of this technology is low or unacknowledged by the industry due to the limited awareness and mixed perceptions on the benefits of identified uses over the risks.

A lively debate – chaired by Dr Moira Dean of Queen's University Belfast – ensued with the panel on the question of whether scientists should communicate more with consumers in the design of nanoproducts. Professor Lynn Frewer indicated that one such project CONNECT4ACTION (http://www.connect4action.eu/) has been established to improve the communication between consumers, consumer scientists, food technology developers, and other key players, in order to improve the success of food technology development and commercialisation in Europe. The workshop illustrated that we are only at the beginning of nanotechnology applications. This means that much more research is required, as well as a balanced debate that involves many stakeholders, including industry, which would draw on different perspectives and highlight the various risks and benefits.

Presentations from this workshop are available at: http://www.teagasc.ie/publications/view_publication.aspx?PublicationID=3096

Acceptance of marine functional foods requires effective communication

Dr Sinéad McCarthy, Research Officer, Food Market & Consumer Research Group, Department of Agrifood Business and Spatial Analysis, Teagasc, Ashtown.
Bridin McIntyre, Research Technician, Food Market & Consumer Research Group, Department of Agrifood Business and Spatial Analysis, Teagasc, Ashtown.
Dr Fiona Manning, NutraMara Programme Manager, Teagasc Ashtown.
Correspondence: sinead.mccarthy@teagasc.ie

Researchers from Teagasc, Ashtown, in the NutraMara consortium are examining consumer attitudes to marine-derived functional ingredients.

The biodiversity of plants and animals found in Irish seas holds great potential for the development of marine functional food ingredients. NutraMara is a multi-centre, trans-disciplinary research programme, focusing on the identification and development of novel bioactive components from marine bioresources for use as ingredients in functional foods. An integral element of the NutraMara programme is to gain an understanding of general consumer attitudes to functional foods and, in particular, to expand on the concept of marine-derived bioactive compounds in functional foods. This research was carried out using a qualitative focus group approach, to deliver an understanding of food and nutrients, to ensure that a discussion around functional foods would be framed in the audience's own language and mindset. Key consumer segments with ranging demographics and at varying stages of life were invited to participate in focus groups to gain an understanding of the extent to which the marine-based functional foods resonated with each segment.

Consumers content with functional foods

Consumers were adept at identifying particular health benefits associated with consuming certain foods. Most notably, fish and seafood featured as one of the perceived healthy foods with many health benefits identified – such as heart health and weight management associated with the consumption of oily and white fish, respectively. A definition of functional foods was given at the groups sessions and few had ever given much thought to this concept, prior to its prompting during the sessions. On balance, most were perfectly comfortable with the concept as illustrated in the following quote: *"So natural foods, enhanced or enriched with something good for you, that doesn't actually exist in that food in the first place"*. Labelling emerged as a concern, this was not felt to be a barrier to functional foods *per se*, rather the benefits of functional foods should be clearly labelled and specific ingredients should be detailed as clearly as possible

Are consumers fishy about marine-derived functional foods?

Following on from these discussions, the more specific concepts of marine-derived functional ingredients were discussed. These concepts included seaweed, chitin (derived from shellfish), and the use of marine-derived ingredients in animal feed to naturally enhance muscle content of the meat. Attitude formation and acceptance of marine ingredients were a function of the health benefit, the source of ingredient, vocabulary used and complexity of use of the ingredient.

The concept of seaweed bread and/or yoghurts was perfectly acceptable to the vast majority of consumers as a potential marine-derived functional food. Some respondents identified seaweed as a proven source of healthy ingredients and there was a reasonable awareness that some seaweed such as Dulse, Carrageen and Kelp have been used for medicinal purposes in Ireland for generations.

This high level of acceptance and willingness to use was clearly evident in the following quotes from one of the groups. *"There was a thing for eating seaweed last week, you take it, you rinse it off and you put it in your salad spinner … you put it on the line until it dries … grind it down and you can put it through anything"; "Sure people have been eating seaweed for hundreds of years"; "It takes on the flavour of whatever you've added it to"*.

Perceived needs

Chitin is a bioactive compound that can be extracted from the shells leftover after the processing of shellfish. The concept of extracting an ingredient from shell material was intriguing for many consumers. While there was no familiarity with the term 'chitin' its scientific ring prompted some respondents' interest regarding the precise health benefits. The key perceived consumer benefits related to the anti-obesity properties. Consumers identified it as important in the fight against childhood obesity, and for adults, where obesity can lead to more serious

medical conditions, e.g. diabetes. Hence, the perceived need is important in acceptance; and clearly a societal need exists for such products in the minds of consumers. Similarly, the potential heart health benefits associated with chitin were also positively received by consumers. Interestingly, the concept of using chitin with the benefit of preventing food spoilage was rejected by the mothers within the context of bread where "*long life*" bread was synonymous with being "*high in preservatives*". This finding very clearly demonstrates that acceptance of chitin is very much a function of the perceived need for the purported benefit. Consumers clearly identify a tangible need in terms of reducing obesity, but not necessarily a need to increase the shelf life of foods such as bread.

Appetite suppression

While products with appetite suppression benefits are likely to meet a consumer need in some segments, the idea of feeding ingredients to animals to modify its inherent meat composition presented major stumbling blocks in the minds of the consumer. This concept represented a step too far for many and evoked associations of Creutzfeldt–Jakob disease (CJD), although some consumers also realised that this was somehow different as illustrated in the following quote: *"But the mad cow, that was cannibalism really with cows, that was dangerous, this is not though"*. This raises issues with regards to a low-level consumer understanding of the concept of animal feeds and meat production process. However, to overcome these issues communication will be crucial and the ultimate acceptance of this concept will require careful education, information and communication of the concept to consumers.

Clear communication: It's the way you tell 'em

The language used to communicate the likely benefits of marine and general functional foods to the consumer is absolutely vital. Terminology around the use of functional food ingredients as 'additives' can suggest to the consumer the addition of a potentially unnatural/unhealthy substance to the carrier food, while the term 'functional' can actually suggest an uninspiring, bland foodstuff of no discernible health benefit.

Breaking down barriers

A series of potential barriers exist, either consciously or sub-consciously in the mind of the consumer. Many of these barriers can undoubtedly be dealt with by way of clear and effective communication strategies. The potentially most debilitating barrier for acceptance and use of functional foods is trust or lack thereof. Concern expressed by some that functional foods in general are likely to be over-priced, and something of a food manufacturer 'gimmick'. Other barriers which would need to be addressed as a matter of priority include:

- Explaining the rationale as to why the maintenance of a well balanced/wholesome diet will not always obviate the need for functional foods.
- Reassurances around the source of any marine resource ingredients used.
- Concerns regarding potential allergic reactions to marine based ingredients, (e.g. shellfish).

Overall, the outlook for acceptance of marine-derived functional foods is positive, however, effective information and education campaigns regarding benefits and safe use of functional food ingredients, as well as targeted marketing to specific consumer segments and careful use of language will play a pivotal role in future acceptance of these foods.

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Making sense of farm sustainability

Dr Thia Hennessy, Head of Department, Agricultural Economics and Farm Surveys Department, Rural Economy and Development Programme, Teagasc Athenry, Co Galway.
Dr Cathal Buckley, Research Officer, Agricultural Catchment Programme, Teagasc Athenry, Co Galway.
Dr Emma Jane Dillon, Research Officer,
Trevor Donnellan, Principal Research Officer,
Dr Kevin Hanrahan, Principal Research Officer,
Brian Moran, National Farm Survey, and
Mary Ryan, Environmental Economics, Agricultural Economics and Farm Surveys Department, Rural Economy and Development Programme, Teagasc Athenry, Co Galway.
Correspondence: Trevor.Donnellan@teagasc.ie

Sustainability is a term now widely used in discussions relating to agriculture and the food sector. Despite this, debate over the concept's precise meaning continues. Sustainable agriculture can mean agricultural production that is in harmony with the environment or, it can also mean a system of production that can secure its own financial future. It can further be thought of in terms of the sociological dimensions of rural life such as work-life balance and age profile. More recently, sustainability has been considered in terms of innovation and technological adoption. Teagasc economists have examined agricultural sustainability across these four dimensions (economic, environmental, social and innovation). Using the Teagasc National Farm Survey (NFS), in conjunction with research from the natural science literature, a range of sustainability measures can be produced. Data presented are representative of 2012 and in future years it will be possible to track progress through time. Within this multidimensional framework a set of farm-level indicators was constructed. The Teagasc NFS allows objective, verifiable and representative data to be compiled, making it an ideal data source for the credible reporting of changes to the sustainability of Irish farms through time. It is possible to compare groups of farms within each enterprise system and draw comparisons between different farm systems. In this article, only a flavour of the content of the study is provided, using a sample of indicators for illustrative purposes.

Economic sustainability

In evaluating the economic sustainability of Irish farms five indicators are reported:

- Productivity of land use.
- Productivity of labour.
- Profitability.
- Market orientation.
- Economic viability.

The NFS reveals the wide range that exists in terms of economic sustainability, both within and between farm systems. Averages are often used in discussions of output and margin per hectare across systems, but behind these average figures lies quite a wide distribution, as evidenced for dairy farms in Figure 1.

Environmental sustainability

In evaluating the environmental sustainability of Irish farms, five indicators are considered.

- Greenhouse gas (GHG) emissions per farm.
- GHG emissions per unit of output.
- Fuel and electricity emissions.
- Nitrogen balance/use efficiency.
- Biodiversity.

Further refinement of the metrics is planned in future versions of the analysis, reflecting improvements in scientific knowledge and greater data collection.

As with economic performance, the analysis indicates a wide variation in environmental performance across farms. Interestingly, a consistent pattern is shown within each of the farm systems, with a positive correlation between economic performance and environmental sustainability. When the farm population is decomposed into top, middle and bottom groups according to profitability, results indicate that the more profitable farms also tend to be those producing food in a more environmentally sustainable manner.

For GHG emissions, as observed in Figure 2, the top performing dairy farms in an economic sense also tend to be the best performing farms from an environmental perspective, i.e., they emit relatively less GHG per unit of product.

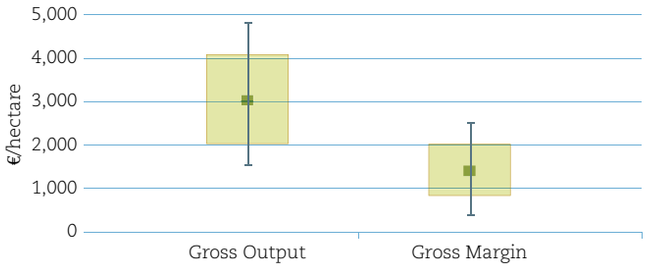


Figure 1: Productivity and profitability: Dairy Farms 2012

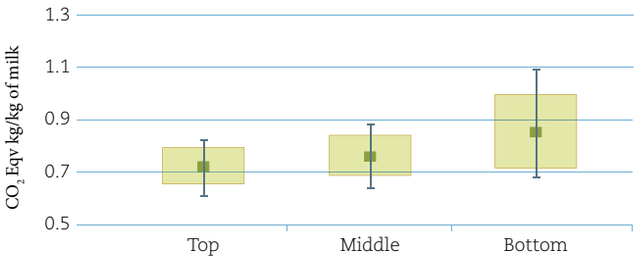
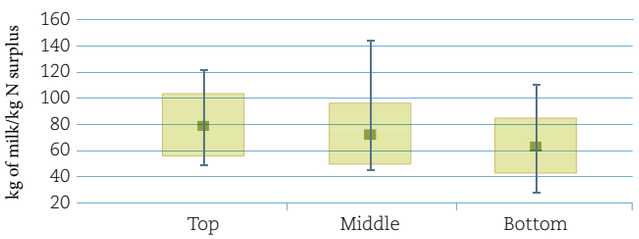


Figure 2: Emissions (CO_2-equiv/kg milk): Dairy farms 2012



Emissions (CO_2-equiv/kg milk): Dairy Farms 2012

In the figures shown, the small square indicates the mean of the distribution, while the surrounding rectangle represents 70% of the distribution.
The whiskers mark the range of 90% of the population distribution. By way of example, looking at Gross Output per hectare on Dairy farms in Figure 1 we see that the average is approximately €3,000, 70% of the distribution lies between approximately €2,000 and €4,000, while 90% of the distribution lies between €1,500 and €4,800.

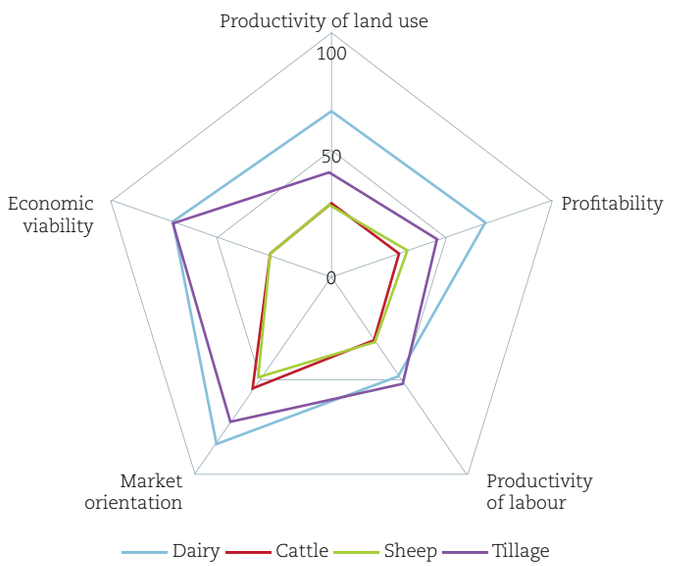


Figure 4: Economic Sustainability of Fams 2012

Interpreting spider diagrams
The diagram is constructed so that zero, or poorest performance, is at the centre of the diagram and 100, or best performance is at the outer edge. In this case, the proximity of the line to the centre is indicative of relatively poorer performance for the system in question across the measures considered.

In terms of environmental sustainability on dairy farms and its positive relationship with profitability, nitrogen balance per hectare is one exception. Nitrogen use efficiency is positively correlated with economic performance across dairy farms (Figure 3), but nitrogen balance per hectare tends to be negatively correlated, i.e., the top performing farms in economic terms have a lower N surplus per kg of product, but tend to produce a greater surplus of nitrogen per hectare.

Social sustainability

Social sustainability indicators are designed here to gauge the quality of life of the farming community with five measures reported upon:

- Household vulnerability.
- High age profile.
- Education level.
- Work-life balance.
- Isolation risk.

From a social perspective, dairy and tillage farms tend to be the most sustainable; but differences are not as pronounced as with the economic indicators. Demography tends to be highly correlated with economic performance, with economically better performing farms in households with a younger age profile. It should be noted that the study does not draw any conclusions about cause and effect.

Innovation

Innovative farm practices deemed appropriate to each of the farm systems analysed are identified and measured. For example, in the case of dairy, participation in milk recording and discussion groups and the timing of slurry spreading were used as a proxy for the farmer's tendency towards innovation. The adoption of innovative practices across systems was shown to be highly correlated with farm economic performance, however, no conclusion is drawn as to which factor drives the other.

Using composite indicators of sustainability

Given that sustainability indicators measure a variety of concepts along a number of different metrics, it is necessary to normalise the indicators to a common scale. A scale from 0 to 100 is used in this case. Spider diagrams are commonly used in the sustainability literature to present these normalised scales.

An analysis of the economic sustainability indicators across farm systems, depicted in Figure 4, indicates that dairy farms, followed by tillage, tend to be the most sustainable.
This is well established in the agricultural economics literature in Ireland and reflects, for example: farm size; land quality; climatic factors; and specific supply and demand factors that can affect the price of individual agricultural commodities.

Conclusions and future work

The quantification of agricultural sustainability through a large set of indicators can be difficult to interpret and it may be useful to aggregate a set of indicators into a single index or composite indicator. Composite indicators are helpful in that they can summarise complex issues, but may lack accuracy unless well-constructed. The study, on which this article is based, concludes with a discussion of the need for future work in this area and, in particular, highlights the importance of the continued publication and further refinement of farm-level sustainability indicators to facilitate an on-going assessment of overall progress towards sustainability objectives across the farm sector.

The full report can be downloaded here:
http://www.teagasc.ie/publications/2013/3042/SustainabilityReport.pdf

Events

March 13 — Horse and Jockey Hotel, Co Tipperary

Dairy Expansion Seminar Series

This first in this seminar series is 'Benchmarking Expansion on Irish Dairy Farms'. This is a high level event aimed at industry CEOs and other senior level farm and processing representatives, input suppliers, the banking sector and agri-food media. Contact: marion.moloney@teagasc.ie
www.teagasc.ie

April 10 — Brussels, Belgium

NetGrow Network Learning Day

To improve innovation, economic growth and sustainable competitive advantage in European food SMEs, the NetGrow project combined scientific research at company level and network level by investigating the drivers and barriers for network learning and network behaviour. This event is organised primarily for network organisations and policy makers at national and EU level, and will offer SMEs a prominent role on the day. In addition to launching the NetGrow Toolbox (a set of tools for improving network learning and network behaviour), challenges in providing policy supports to SMEs and network organisation will be also a prominent agenda point. Teagasc was a Work Package leader on the project and on the organising committee for the event. Dr Maeve Henchion is chair of the Project Management Committee.
Contact: maeve.henchion@teagasc.ie — http://netgrow.eu/

April 15 — RDS, Dublin

Teagasc Lecture Series – Lecture 4: Is Better Global Governance of the Food System the Answer?

The transitions required to an economy which sustainably uses scarce natural resources is dependent for success not alone on technological breakthroughs, changing consumer behaviour and market reforms, but also on the successful operation of some system of multilateral governance that will promote consultation and cooperation between nations. The questions arise as to who will lead these transitions and who will take the decisions? Despite long-standing acceptance of the need to conserve biodiversity and achieve sustainable development, both of these goals still remain as aspirations, representing failure both on the part of governments and of the market. While some individual governments are responding to the opportunities presented by investment in the 'green economy', national-level efforts will not be enough. International collective action will also be needed to tackle global-level challenges.The speaker, Dr Maximo Torero, is the Division Director of the Markets, Trade, and Institutions Division at the International Food Policy Research Institute (IFPRI), Washington, DC, leader of the Global Research Programme on Institutions and Infrastructure for Market Development and Director for Latin America.
teagasclectures@conferencepartners.ie
Register online: http://bit.ly/1jYEO6X

April-May — Nationwide

Smart Futures

Smart Futures is a collaborative programme between Government and industry that promotes careers in science, technology, engineering and maths (STEM) to post-primary students, parents and guidance counsellors.
Smart Futures is partnering with SciFest, a national science competition that sees schools across Ireland take part in science fairs. Students with winning projects going on to compete in regional heats in the Institutes of Technology in a bid to make it to the national final. Smart Futures is delivering STEM career talks to students at these regional events in a number of Institutes of Technology and Teagasc researchers will be talking to students at: Athlone IT (April 30), Limerick IT (May 2), Dundalk IT (May 7), Tralee IT (May 8), Letterkenny IT (May 9), Sligo IT (May 14).
www.SmartFutures.ie — www.SciFest.ie

May (tbc) — Teagasc Ashtown Conference Centre

Food Innovation Gateways Event

Food Harvest 2020 has targeted 40% growth in output for the beef and sheepmeat sector. This will be challenging given the competitive nature and associated tight margins of the global market in which this sector operates. To be successful the industry will need an innovation capability that can exploit existing pre-competitive research expertise and influence the prioritisation and development of such research by public research organisations (Teagasc, Department of Agriculture, Food and the Marine, Enterprise Ireland, Bord Bia).
This event will: showcase the range of pre-competitive research relevant to the Irish meat industry that is being undertaken within the UCC/Teagasc Food Innovation Alliance; demonstrate examples of successful knowledge transfer from the research teams to the agri-food sector; outline and consider models of innovation in other sectors that may present useful models for the meat industry; help develop the vision for creating sustainable competitive advantage for the Irish meat sector built on innovation capability that runs end to end from farm output through individual meat processing sites to customer application; and prioritise an approach for building a unique research competence and capability in the specific characteristics of the Irish meat industry.
This event is aimed at thought leaders of the Irish meat processing industry, as well as key stakeholders within the wider food industry.
There will be presentations by thought leaders detailing innovation success stories and opportunities for the meat processing industry. Following on from this, representatives from the Irish food innovation support ecosystems (research institutes, universities, Government agencies and food industry membership organisations) will exhibit their capabilities and will be available for one-to-one discussions with delegates.

June 18-19 — La Rochelle, France

1st International PLEASURE conference – 'Salt-sugar-lipids reduction'

This is a dissemination event for the FP7-funded PLEASURE project, of which Teagasc is a partner. Teagasc leads the Work Package on the technological challenges of simultaneously reducing fat and salt contents in cheese.
PLEASURE is a research project aiming to find solutions to today's excessive consumption of salt, sugar and saturated fats, by designing different products that have a lower content of these components. PLEASURE approach is unique, as it is the first attempt of reducing salt, sugar and fat content in food products, from the processing side, by developing innovative processes that will work by optimising the sensorial perception.
Contact: phil.kelly@teagasc.ie — www.pleasure-fp7.com/conference

June 22-26 — The Convention Centre, Dublin, Ireland

Plant Biology Europe FESPB/EPSO 2014 Congress

Teagasc is a sponsor of this international event that brings together The Federation of European Societies of Plant Biology and the European Plant Science Organisation congresses. The congress covers all aspects of plant biology, including everything from abiotic stress to big data in plant science. Abstracts for poster presentations will be accepted up to March 21.
Contact: registration@europlantbiology.org — http://europlantbiology.org/

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