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T Research

Research and innovation news at Teagasc

Milk quality - increasing production while maintaining standards

- *Food Harvest 2020*: a brighter shade of green?
- Making the most of colostrum
- Improving forage maize production in Ireland

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Agriculture and Food Development Authority

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TResearch is an official science publication of Teagasc. It aims to disseminate the results of the organisation's research to a broad audience. The opinions expressed in the magazine are, however, those of the authors and cannot be construed as reflecting Teagasc's views. The Editor reserves the right to edit all copy submitted to the publication.

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Laying out the future for research in Ireland

The Government recently launched a very important plan for the future of research in Ireland. The aim of the plan is to target the Government's annual research spend of €500 million at areas with the greatest potential for economic return. Fourteen opportunity areas have been identified that include 'Sustainable Food Production and Processing' and 'Foods for Health', which are of direct relevance to the agri-food industry and are now recognised in the Government's research funding priorities.

The plan results from a review that was carried out by an independently constituted Research Prioritisation Steering Group. This is the most important review of the State's research funding policy since the Technology Foresight exercise in the late 1990s, which gave priority to ICT and biotechnology. It is widely agreed that this has given Ireland a strong science base, and the current thinking is that we must build on those strengths and target funding at areas with the greatest potential for economic return.

The Government will set up a Prioritisation Action Group, which will oversee implementation of the recommendations of the report. Membership of the group will include all Government agencies that are responsible for research budgets (including Teagasc) and their parent Departments, i.e., the Department of Agriculture, Food and the Marine (DAFM). One important change is that a two-stage evaluation process will be implemented for all research proposals: they must pass a test of relevance and potential impact before being assessed for scientific excellence. There will be annual external review on the performance of the research programme in relation to targets that reflect outcome and impact. Another important metric will be the amount of funding that research programmes can leverage from industry.

The medium term goals for the agri-food sector are clearly laid out in DAFM's *Food Harvest 2020*. DAFM is the main funder of agri-food research, mainly through its funding to Teagasc and also through competitive funding schemes such as FIRM, Stimulus and CoFoRD. The challenge for research now is to meet the knowledge needs of *Food Harvest 2020* by carrying out high quality, relevant research that has a positive impact on the sector.

Dr Frank O'Mara,
Director of Research

Ag leagan amach na todhchaí le haghaidh taighde in Éirinn

Lainseáil an rialtas plean an-tábhachtach le haghaidh todhchaí an taighde in Éirinn. Is é is aidhm leis an bplean caiteachas bliantúil taighde an rialtais de €500 milliún a dhíriú ar réimsí ina bhfuil an acmhainneacht is mó maidir le toradh eacnamaíoch. Sainaithníodh ceathair déag réimse deise ar a n-áirítear 'Táirgeadh agus Próiseáil Bia Inmharthana' agus 'Bianna ar son na Sláinte', a bhaineann go díreach leis an tionscal agraibhia agus a aithnítear anois i dtosaíochtaí maoinithe taighde an rialtais.

Is toradh é an plean ar athbhreithniú a rinne Grúpa Stiúrtha um Beartú Tosaíochta Taighde atá comhdhéanta go neamhspleách. Is é seo an t-athbhreithniú is tábhachtaí ar pholasaí maoinithe taighde an Stáit ón gcleachtadh maidir le Fadbhreathnaitheacht Teicneolaíochta ag deireadh na 1990idí, inar tugadh tús áite do TFC agus biteicneolaíocht. Comhaontaíodh go mór gur thug sé seo bonn láidir eolaíochta d'Éirinn, agus is é an smaointeoireacht reatha go gcaithfimid forbairt ar na láidreachtaí sin agus maoiniú a dhíriú ar réimsí ina bhfuil an acmhainneacht is mó maidir le toradh eacnamaíoch.

Bunóidh an rialtas Grúpa Gníomhaíochta um Beartú Tosaíochta a dhéanfaidh maoirseacht ar chur i bhfeidhm na moltaí sa tuarascáil seo. Áireofar i mballraíocht an ghrúpa gach gníomhaireacht Rialtais atá freagrach as buiséid taighde (lena n-áirítear Teagasc) agus a máthair-Ranna, .i. an Roinn Talmhaíochta, Bia agus na Mara (DAFM). Is é athrú tábhachtach amháin go gcuirfear próiseas meastóireachta dhá chéim i bhfeidhm maidir le gach togra taighde: ní mór dóibh tástáil ábharthachta agus iarmhairt fhéideartha a ghnóthú sula ndéanfar measúnú orthu le haghaidh sármhaitheas eolaíochta. Déanfar athbhreithniú seachtrach bliantúil ar fheidhmíocht an chláir thaighde i ndáil le spriocanna a léiríonn toradh agus iarmhairt. Méadrach tábhachtach eile a bheidh i gceist ná an méid maoinithe is féidir le cláir thaighde a ghiaráil ó thionscal.

Tá na spriocanna meántéarmacha maidir leis an earnáil agraibhia leagtha amach in *Food Harvest 2020*. Is é DAFM a thugann an príomh-mhaoiniú le hagahidh taighde agraibhia, trína mhaoiniú do Teagasc agus trí scéimeanna maoinithe iomaíocha chomh maith amhail FIRM, Stimulus agus CoFoRD. Is é an dúshlán le haghaidh taighde anois riachtanais eolais *Food Harvest 2020* a bhaint amach trí thaighde ardchaighdeáin, ábhartha a dhéanamh a bhfuil iarmhairt dheimhneach aige ar an earnáil.

Dr Frank O'Mara
An Stiúrthóir Taighde

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Maeve Henchion

Maeve recently took up the post of Head of the Agrifood Business and Spatial Analysis Department, Rural Economy and Development Programme, *Teagasc* Research Centre, Ashtown, Dublin - one of the newest departments within *Teagasc*'s research directorate. The department was formed in January 2011 following the merger of the Food Market Research team (Ashtown), the Spatial Analysis Unit (formerly Kinsealy) and the Agri-Innovation and Learning Group (Athenry).

Prior to her appointment, Maeve spent 16 years working with *Teagasc*'s Food Research Programme.

"After completing my primary degree in Agricultural Science in UCD in 1991, I developed an interest in food marketing through a MSc with Dr John O'Connell in UCD." This led to further study and the completion of a *Teagasc*-funded PhD in 1996, evaluating the export market performance of Irish beef. Following this, Maeve spent about six months in Africa and, while a facinating experience, the lure of a post in *Teagasc* proved too strong! "Once the recruitment embargo (they had them then too!) was lifted, I took up my first post with *Teagasc* in 1996 as a contract research officer supporting research led by Eamonn Pitts." Additional contract positions within the organisation followed as Maeve participated in a number of national and EU-funded projects until Maeve was appointed to the permanent research staff in 2003 with responsibility for enhancing the market orientation of the Food Programme. Development of this aspect of *Teagasc*'s research portfolio was achieved through continuous engagement with colloborative national and international research networks.

Maeve is currently the Irish principal investigator on Netgrow, an FP7 project. This study explores SMEs engagement with networks and the impact of these interactions on their levels of innovation. Maeve is also leading a FIRM-funded project that examines consumer and industry acceptance of novel food technologies. In addition to communicating the results of research through conventional channels - i.e., journals, book chapters and reports - Maeve is keen to reach the broader audience of *Teagasc* stakeholders through popular media. She was one of the key drivers of the *Teagasc Food Innovator* newsletter and has edited all issues to date. Being a scientist specialised in food marketing lends itself to working with a diverse range of partners across disciplines, and ultimately to publication in assorted journals including *Meat Science, AgBioForum, European Review of Agricultural Economics, Food Quality and Preference, International Journal of Retail and Distribution Management, Journal of International Food and Agribusiness Marketing* and *British Food Journal*.

Hailing originally from Cork, Maeve now resides in Dublin. She has a keen interest in the Irish language and is part of a local Irish conversation group, as well as helping to coach the U8s gaelic and camogie teams at her local GAA club. Beyond that she says her four children take up the rest of her spare time!

Pictured are (clockwise from bottom left) Gerry Boyle, Chief Executive, Teagasc; Aidan Cotter, Chief Executive, Bord Bia; Minister for Agriculture, Food and the Marine, Simon Coveney, Mary Ann O'Brien, Food Entrepreneur/ founder of Lily O'Brien Chocolates; Frank Ryan, Chief Executive, Enterprise Ireland; and, Minister for Research & Innovation, Seán Sherlock.

Food Works

Bord Bia, Enterprise Ireland (EI) and Teagasc have launched a new collaborative initiative in an effort to support and foster the global food entrepreneurs of the future. The organisations are looking for determined, energetic and well-accomplished individuals, who may have worked at a senior level in the food business or have shown entrepreneurial flair in another sector. Successful participants will be given an invaluable range of practical business supports required to develop an initial concept into a winning food product with international appeal. The available supports will include consumer market research, business plan development, technical advice, commercial viability testing in addition to access to incubation units, research and development (R&D) facilities and possible investors. Speaking at the launch, Minister for Agriculture, Food and the Marine, Simon Coveney, said: "Food Works is a unique opportunity for ambitious and determined new food entrepreneurs to build great food businesses. Food Works is an example of development agencies working together in a new way to improve the climate and opportunities for growth and I look forward to it fostering new food businesses with high potential for development." Candidates may apply on an individual basis, as part of a team or a company if it has been in existence for less than two years. For more information on Food Works or to register for the initial information evenings, visit **www.foodworksireland.ie**

Recognising excellence

The Teagasc Staff Excellence Awards were announced recently. The awards aim to recognise and reward excellence, encourage best practice, foster ongoing professional development and provide a platform to showcase achievements at Teagasc.
Among the award-winners were: Drs Chris Creevy and David Lynn for demonstrating excellence in research, through establishing computational biology in animal bioscience programme and accelerating it to high performance in external income and publications; Dr Paul Cotter for his outstanding achievements as a microbial microbiologist, improving the shelf life and safety of food; Dr Matt McCabe for his provision of technology support to establish advanced molecular biology techniques in the Animal Biosciences Programme; and the Teagasc Water Framework Directive Working Group for excellence in promoting organisational integration. Commenting on the awards, Gerry Boyle, Director, Teagasc, said: "We are proud to recognise, reward and celebrate the excellent achievments of our staff." Award winners are also considered as Teagasc nominations for the biannual Taoiseach's Award.

Farmer discussion group, Ethiopian style: Teagasc's Denis Griffin (standing fifth from left) and Rogier Schulte (second from right) at the kick-off meeting of the Chencha project.

Food security and climate change at lower latitudes: the Chencha project

Teagasc, together with Vita and Wageningen University (The Netherlands), has initiated a collaborative research project with the Ethiopian Institute of Agricultural Research, Hawassa University and CIP-Ethiopia to promote sustainable food security at farm level in developing countries. Specifically, it aims to develop sustainable seed potato production systems in the Chencha woreda, with potatoes being promoted as a 'hunger-busting' crop that is highly suitable to the climatic conditions of the Ethiopian highlands.

The project recruited three Ethiopian PhD students, who are pursuing their doctoral studies through Wageningen University as Teagasc Walsh Fellows. Following initial training in the Netherlands and at various Teagasc centres, these students will be based in Chencha, and will pursue their studies through participatory, on-farm research. They will work directly with the target farmers to develop seed potato systems that are more productive, environmentally sustainable and resilient to the potential impacts of climate change.

The Science Squad

Dr Donagh Berry, Teagasc, Moorepark, is pictured being interviewed by Katriona Devereux and Ciaran O'Connor, Camera/Director, New Decade Television and Film Production, for the new television series 'The Science Squad' to be broadcast on RTÉ in summer 2012.

Dr Ingrid Aguiló-Aguayo

Post-doc in Pulsed Electric Fields

Dr Ingrid Aguiló-Aguayo recently commenced a post-doc at Teagasc Food Research Centre, Ashtown. Ingrid will be using her expertise in Pulsed Electric Fields (PEF) technology, together with Dr Juan Valverde, as part of the Irish Phytochemical Food Network, to determine the effects of PEF in carrot and broccoli food products and their associated bioactive content, relating specifically to glucosinolates and polyacetylenes. The UCD Institute of Food and Health will be also integrated in the project.

PEF has been shown to be an interesting technology for food processing since high-quality, safe and shelf-stable products can be obtained without significant depletion of their nutritional and sensory properties. Funding for the post-doc came from the Generalitat of Catalunya (regional government in Spain) for the post-doctoral grant Beatriu de Pinós.

Top downloaded paper

The paper 'Milk intelligence: Mining milk for bioactive substances associated with human health', featuring collaborative work from Teagasc and UCC under Food for Health Ireland (www.fhi.ie), was the top downloaded paper for 2011 in the *International Dairy Journal*. The paper examined research which is unveiling an ever-accumulating range of bioactivities associated with milk substituents, emphasising a role in programming human health. The paper appeared in Volume 21, Issue 6, June 2011, pages 377–401 **(http://dx.doi.org/10.1016/j.idairyj.2010.12.011)**

Five new Teagasc-bred grass varieties recommended

Five new Teagasc-bred perennial ryegrass varieties have been added to *Grass and Clover Recommended List of Varieties for Ireland 2012*, published by the Department of Agriculture, Food and the Marine. The varieties have been shown to offer improved yield, quality and persistence characteristics for grass-based production systems in Ireland.

The new Teagasc-bred perennial ryegrass varieties are: Genesis (early diploid), Carraig (intermediate tetraploid), Majestic (late diploid), Glenveagh (late diploid) and Kintyre (late tetraploid).

Genesis has the highest spring yield and Glenveagh the highest ground cover of all perennial ryegrass varieties on the recommended list. Carraig has the highest spring yield and ground cover of all intermediate tetraploid varieties. Kintyre has the highest annual yield, and joint highest autumn yield and digestibility of all late heading varieties. Majestic combines high all round performance in yield and ground cover.

In 2012, farmers may choose among 12 perennial ryegrass and three white clover varieties bred by Teagasc for reseeding. All varieties are included on the *Grass and Clover Recommended List Varieties for Ireland 2012*.

The Teagasc forage breeding programme continues to develop improved varieties of grass and clover. A number of other new varieties are currently undergoing seed increase for future release.

The list is available at the Department of Agriculture, Food and the Marine's website: **http://www.agriculture.gov.ie/publications/2012**

Delegates at the recent ProsafeBeef conference.

ProSafeBeef conference

A major international conference on beef 'Advancing Beef Safety and Quality through Research and Innovation' took place recently at the Teagasc Food Research Centre, Ashtown, Dublin. At the two-day 'ProSafeBeef' conference, presentations on a range of new technologies to monitor and assure beef safety, as well as new beef product and process technologies to improve beef quality, was presented to delegates. A number of these technologies have already been successfully adopted by the beef industry across Europe and more have been brought to prototype and are ready to progress towards a commercialisation phase.

ProSafeBeef is a large European Commission research project co-ordinated by Dr Geraldine Duffy and Mr Declan Troy at Teagasc Food Research Centre, involving 41 leading international beef research and industrial companies from 15 countries across Europe, North and South America and Australia.

Jim O Mahony and Dr Helen Grogan, Teagasc (Front row, second and third from left) at the inaugural meeting of the FP7 funded project 'MushTV' along with 12 of the 16 partners.

MushTV project begins

A new industry-driven research project, worth €2.6 million, has been set in motion with funding secured from the EU under the FP7 Capacities programme 'Research for the benefit of Small to Medium-Sized Enterprise (SME) Associations'. MushTV aims to investigate and develop improved management techniques for two important mushroom diseases - *Trichoderma aggressivum* and Mushroom Virus X. Sixteen partners from Ireland, the UK, the Netherlands, Belgium and Poland are in the consortium, which is being coordinated by Dr Helen Grogan of Teagasc. The group includes six grower associations (CMP-Ireland, AHDB-UK, Funghi and CNC-Netherlands, VOC Belgium and SBGU-Poland) representing over 300 mushroom growers across Europe, as well as a number of commercial compost producers. Five research organisations (Teagasc-Ireland, AFBI-Northern Ireland, EMR-UK, PRI-Netherlands and INAGRO-Belgium), have been subcontracted by the SME Associations to conduct research on behalf of their grower members. This is the first time that so many mushroom-related businesses have come together to work towards solutions to common problems. The project runs for three years.

Pictured at the conference are: Michael Hennessy, Richie Hackett, Dermot Forristal and Steven Kildea, all of Teagasc, Oak Park.

Record yields in 2011

Tillage farmers attending the recent Teagasc National Tillage Conference in Kilkenny heard that Ireland has globally high cereal yields and, over the last decade, the highest average wheat and second highest average barley yields in the world. Speaking at the conference, John Spink, Head of Crops Science, Teagasc, said that despite this history of high yields, 2011 produced some of the highest yields on record, with an average increase of 13% on 2010 yields.

"Favourable weather conditions in the spring resulted in good leaf and tiller formation, resulting in increased crop canopy sizes and ear numbers. This early spring growth was particularly important for spring barley. From May to harvest, temperatures were below normal and average solar radiation was above normal, which combined to prolong grain fill and allow crops to fill the high grain numbers. This combination of weather conditions resulted in the record yields achieved in 2011," he explained.

Menawhile, Professor Ian Crute, chief scientist at the Agriculture and Horticulture Development Board in the UK, delivered the keynote address on the topic of 'Challenges and Opportunities for Northern European Agriculture' saying that the global food system needs radical redesign. Challenges facing the sector, he said, include: balancing future demand and supply sustainably; addressing the threat of future food price volatility; ending hunger; food production in a low emissions world; and maintaining biodiversity and ecosystem services while feeding the world.

Product shelf-life

A Seminar on 'Product Shelf-life and Microbiological Criteria', organised by Teagasc and The Food Safety Authority of Ireland, took place in November 2011 at the Teagasc Food Research Centre, Ashtown, Dublin.

Pictured at the event were: Dr Wayne Anderson, Food Safety Authority of Ireland; Ita White, Teagasc; Shane McEntee, Minister of State at the Department of Agriculture, Food and the Marine; Professor Gerry Boyle, Teagasc Director; and Dr Gerard Barry, Teagasc (see article on page 38). .

Field studies using GM potatoes

Teagasc has applied to the Environmental Protection Agency for a licence to undertake a series of field studies using GM potatoes resistant to potato late blight disease to determine the potential impact this technology could have on our ecosystems. As part of the 22-partner 'AMIGA' consortium, which represents 15 EU countries and is funded through the EU's Framework 7 research programme, Teagasc proposes to carry out the research over the next four years. Pending license approval, the work will take place at the Teagasc Crops Research Centre in Oak Park, Carlow.

Research confirms that GM late blight resistant potatoes have the potential to significantly reduce the fungicide load on the environment and hence provide an economic advantage to farmers. However, Teagasc researcher Dr Ewen Mullins, stresses: "It is not enough to simply look at the benefits without also considering the potential costs. We need to investigate whether there are long-term impacts associated with this specific GM crop and critically we need to gauge how the late blight disease itself responds. This is not just a question being asked in Ireland. The same issues are arising across Europe."

Teagasc will also conduct an outreach programme with stakeholders and the public through focus groups and open days, to facilitate an inclusive and impartial discussion on the issues that most concern people. Head of crops research in Teagasc John Spink said: "Teagasc are clear that their work is not about testing the commercial viability of GM potatoes. The GM study is about gauging the environmental impact of growing GM potatoes in Ireland and monitoring how the pathogen, which causes blight, and the ecosystem reacts to GM varieties in the field over several seasons."

Dr Tassos Haniotis at the recent international economics conference.

Economics conference

Extreme price volatility in agricultural commodity markets was a key topic at a major international economics conference hosted by the Teagasc Rural Economy and Development Programme and the Agricultural Economics Society of Ireland recently at the RDS, as part of Dublin City of Science. The event attracted approximately 100 economists working in this area from around the world who came to Ireland to hear presentations based on 70 papers on this topic.
Speaking at the event, Dr Tassos Haniotis of the European Commission, highlighted the key factors driving agricultural price volatility, emphasising that agricultural input price movements were a big component of farm income volatility and that addressing output price volatility alone would not be likely to stabilise agricultural incomes.
Dr Jesús Antón of the Organisation for Economic Co-operation and Development (OECD) argued that the role of governments should be to help farmers assess and manage their own risks rather than necessarily attempting to insulate farmers from risk. Meanwhile, Dr Seth Meyer of the Food and Agriculture Organisation (FAO) stated that the emergence of biofuel policies has deepened the integration of agricultural and energy markets, emphasising that the integration of agricultural and energy markets now also directly affects the price of agricultural commodities such as maize, rapeseed and sugar.

Teagasc Gold Medal winner

Professor Paul Ross, Head of the Food Research programme, has been awarded the Teagasc Gold Medal. The award is presented to Professor Ross in recognition of his achievements during his career in Teagasc since joining the organisation in 1993. In July 2009 he took over as Head of the Teagasc Food Research programme, responsible for the research activities at Moorepark and Ashtown locations. The Teagasc Gold Medal is awarded on an annual basis to a serving staff member who has made an outstanding contribution to the organisation and to the agri-food sector.

Outlook 2012 conference

At the Outlook 2012 Conference, held in January, Teagasc economists provided a review of prospects for agricultural and farm input prices and farm profitability in 2012. For the first time the event was held in Kilkenny and attracted over 200 participants, mainly from the agribusiness community.
Delegates heard that the outlook for most sectors, while still broadly positive, is not as good as it was 12 months ago. The pig sector is likely to be an exception to this general picture and should have a better year in 2012.
For other sectors, falling international agricultural commodity prices and high input costs are likely to give rise to reduced farm profitability in 2012. The forecast for the sector as a whole remains highly dependent on circumstances in the wider EU and in the developing world. The conference also included a special session on the upcoming CAP reform, with speakers drawn from all of the main farm organisations.

State visit

Sean Sherlock (third from left), Minister of State, Department of Enterprise, Jobs & Innovation and Department of Education & Skills with responsibility for Research & Innovation recently paid a visit to Teagasc Moorepark. Teagasc staff pictured (from left) are: Dr Mark Fenelon; Professor Paul Ross; Professor Gerry Boyle, Teagasc Director; Kieran Downey, General Manager, Moorepark Technology Limited; and Dr Tom Beresford.

Teagasc event proceedings and presentations can be found online at: **www.teagasc.ie/publications/**

Opportunities for cheese/dairy industry

Teagasc's Technology Transfer Office provides details of a specific patented cheese technology and expertise in cheese available at Teagasc.

Commercialisation opportunity

Whey-less cheese manufacture based on patented novel cheese technology platform (NCTP)

Teagasc is seeking additional industrial partners within the ingredient and retail cheese industry with a view to licensing NCTP for the production of innovative cheese solutions and health cheeses.

Summary

The rapidly growing market for ingredient cheese is currently being served by traditionally-manufactured table cheeses. Teagasc has developed a dedicated process for direct manufacture of ingredient cheese tailored to customer requirements. As NCTP does not require whey expulsion, it lends itself to new generation health cheeses and increased control of cheese characteristics.

Problem

Conventional manufacture of natural cheese is quite limited in terms of cost-competitive, customised ingredient solutions, reliance on a source of fresh milk and a large volume of 'unclean' whey, i.e., loss of added materials (e.g., prebiotics). Until now, it has not been possible to reconstitute available dairy ingredients in the concentrated form that corresponds to the targeted cheese types.

Solution

NCTP is free from the technological and functional constraints in conventional cheese manufacture. This results in increased control of ingredient cheese solutions and provides a platform for the design and manufacture of cheeses with varying dry matter content and customised properties. NCTP customises the functionality of a milk protein-based ingredient and thus its subsequent transformation into cheese. Resultant cheeses may be either cast cheese (<48% dry matter (DM)) formed by rennet/acid treatment of re-assembled milk and/or structured cheese (up to 60% DM) formed by further curd treatment.

Opportunity

Develop a novel range of prototype functional casein-based ingredients, with NCTP, where the pH, buffering capacity and casein-to-whey protein ratio of the resultant cheese can be targeted.

While Teagasc is currently engaged in a collaborative project with a company involving NCTP we welcome further expressions of interest in order to extend its applicability to other cheeses.

Expertise offer

Expertise in cheese

Background

The fundamental knowledge of the critical factors affecting the composition, yield, biochemistry, rheology, and cooking properties of natural cheeses and processed cheese products are well understood at Teagasc and, through our Food Research Centre at Moorepark, we have extensive expertise in a variety of cheese types. This, combined with an active ongoing research programme, allows us to offer a range of leading-edge technologies to support the innovation of cheese products and optimisation of cheese-making efficiency.

Benefits to industry

Engagement with Teagasc gives access to state-of the art facilities and our extensive research expertise in all aspects of cheese science and technology. Through consultancy services, contract research and collaborative arrangements, we can assist with the innovation of new cheese products and optimisation of manufacturing efficiency.

Facilities/equipment

- Pilot plant facilities for milk standardisation equipment, pilot scale cheese vats (500-3000L)
- Cookers for processed/analogue cheeses
- Ripening rooms, mixers, culture production unit for specialised starter blends
- Filtration and dehydration equipment for manufacture of ingredients for use in cheese products.

Areas of expertise

- Texture and functionality of natural cheese and processed/analogue cheese
- Increasing manufacturing efficiency and component recoveries
- Cheese flavour control and diversification including identification and selection of micro-organisms with potential to influence flavour development
- Development, scale-up and diversification of a range of cheese types: brine salted, dry salted, reduced-fat variants.
- Advanced methodologies for assaying cheese texture and functionality
- Range of analytical capabilities for composition, biochemistry, microbiology, rheology, and functionality.

This research was supported by the Enterprise Ireland Commercialisation Fund and the National Development Plan.

For more information on these and other offers see the Technology Transfer Office's website:
www.teagasc.ie/research/collaboration/ or contact techtransfer@teagasc.ie

The value of agricultural and food research

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Dr Frank O'Mara outlines the impact and value for public money of agricultural and food research.

Assessing science impact

While it is usual and common to evaluate research programmes in terms of inputs (expenditure, personnel, resources) and outputs (scientific publications, citations, conference presentations, patents, etc.), impact-based assessment is needed to quantify the ultimate impact on economic activity of the research programmes relative to the level of research costs and the value for public money. There are internationally accepted methodologies for carrying out such impact-based assessments and many such assessments of the value for public money from agricultural research have been made internationally.

Irish study

In 2002, Boyle *et al.* published the results of seven such case studies of agriculture research programmes operating in Ireland. These show a very satisfactory value for public money when the impact of the research programmes is evaluated (Table 1). The estimated average internal rate of return was 55%, which compares very favourably with most other public sector investment projects. The returns estimated from these seven Irish case studies are comparable to international estimates, which were reported to be in the range 40 to 50%, as discussed further below.

UK study

A recent major Foresight study conducted for the UK Government, *Global Food and Farming Futures,* examined this issue and reviewed the international literature in relation to evaluation of agriculture research funding. It concluded that the rates of return were high. For instance, it quotes a study by Beitema and Koc (2009) that reviewed several meta analyses of the rates of return to agricultural R&D covering more than 1,000 studies, which reported internal rates of return of between 20% and 80% per annum. Another study quoted is that of Alston *et al.* (2000), which reviewed 292 studies reporting returns to agricultural R&D, and, when outliers and incomplete observations were omitted, it found that regression analysis of 1,128 estimates produced annual returns with a mean of 64.6%. Two other interesting points were made in this Foresight study:

- As well as gains in productivity and economic return, agricultural research produces social, environmental and policy impacts. Examples of this are contributions to food security, the long-term decline in relative food prices, and the contribution to regional economic development because of its locally dispersed nature.
- The consequences of the decrease in public investment in agriculture R&D, and the increasing focus of the reduced expenditure on environmental concerns over recent decades, are now starting to emerge as a reduction in the growth of productivity. For example, the study refers to the relative rates of yield increase for major grain crops, which were around 2-3% per annum in the 1980s, but are now significantly less (typically 1-1.5% per annum), and there is evidence of crop yields not increasing at all in some locations.

Table 1. Summary of estimate research costs and benefits of seven case studies examined by Boyle *et al*. (2002).

	PERIOD OF RESEARCH	END DATE FOR STUDY PURPOSES	SUM OF GROSS REAL BENEFITS	DISCOUNTED SUM OF GROSS REAL BENEFITS	SUM OF REAL PROGRAMME COSTS	DISCOUNTED SUM OF REAL PROGRAMME COSTS	DISCOUNTED BENEFIT-COST RATIO (DBCR)	NET PRESENT VALUE (NPV)	INTERNAL RATE OF RETURN (IRR %)
Potato breeding research	1962-1998	1998	€106.7m	€18.8m	€24.1m	€9.5m	2	€9.3m	9
Milking machine research	1975-1998	1998	€799.5m	€242.7m	€6.4m	€3.8m	67	€239.0m	44
Silage research	1960-1990	1999	€5.7b	€1.3b	€42.6m	€17.7m	77	€1.3b	46
Malting barley research	1985-1995	1999	€73.7m	€36.8m	€2.1m	€1.7m	22	€35.6m	95
Pig breed evaluation research	1990-1998	1999	€16.5m	€8.9m	€1.0m	€0.8m	12	€8.9m	74
Phosphorus on grassland research	1986-1998	1999	€269.2m	€115.6m	€1.1m	€0.8m	140	€115.6m	69
Mushroom-growing research	1969-1995	1999	€825.5m	€362.0m	€5.5m	€2.4m	153	€199.4m	47

DBCR: This is the ratio of the discounted stream (at 5% per annum) of benefits to the discounted stream of costs, both denominated in constant prices, from the inception of the programme up to a termination date.
NPV: This involves discounting the stream of net benefits, denominated in constant prices, from the inception of the programme up to a termination date by an assumed discount rate (5% as recommended by the Department of Finance). While a positive number indicates value for money, the bigger the number the better the return and thus the measure can be used to rank diverse projects in terms of the scale of the project.
IRR%: this is the rate of discount that ensures that the sum of the stream of net benefits, denominated in constant prices, from the inception of the programme up to a termination date, is zero. An IRR in excess of 5% would indicate good value for money. Moreover, the typical IRR for "successful" research projects in the international literature is substantially in excess of 5%.

US studies

A recent US study (CAST, 2011) made similar conclusions about the return on investment in agriculture research. It also outlined the reasons why public-funded research was needed and why the task could not be left (solely) to the private sector. The report concluded that the private sector faces weak incentives to undertake research in numerous areas. Although it invests large amounts in R&D, which lead to innovations that help raise agricultural productivity and improve the quality of life, the private sector focuses primarily on areas that have significant profit opportunities, meaning a market with strong intellectual property rights and regulatory systems in place. Some examples given of why public agricultural research is needed included:

- Farms are too small and certain crops are too minor to bear the cost of R&D to develop most new farm technologies.
- Private agribusiness firms cannot expect to recoup enough benefits to cover the costs of innovations that (1) decrease soil and water erosion and improve air and water quality; (2) analyse impacts of commodity and trade policies; and (3) reveal new information about diet, nutrition and health, as well as about rural and community development.
- Farmers and consumers need transparent, objective information so that they can make good investment, production, and consumption decisions, but strong intellectual property rights are critical to open information sharing. Intellectual property rights are a key driver of investment in R&D, innovation and knowledge dissemination in the public and private sectors. Published patent documents offer a vast, accessible source of cutting-edge technological information. Moreover, charging for outlook information, which is a public good, unduly restricts its use.
- Private firms have limited interest in on-site training of new scientists for the future. Major doctoral student training is not and will not be undertaken by private firms.

Future agricultural policy

Another US report (CAST, 2010) concludes that while great strides were made in agricultural productivity over recent decades as a result of research, the convergence of challenges now facing the sector at one time is unprecedented. These challenges include meeting developed countries' increased demands on agriculture for fuel and ecosystem services; further increasing production per unit of land, water, and nutrient resources; dealing with global population growth; and serving the increased food demands in developing countries. It concludes that future agricultural policy for all nations must include a strong commitment to science if nations are to meet the coming challenges successfully. These challenges are both challenges and opportunities for Ireland and our agri-food sector.

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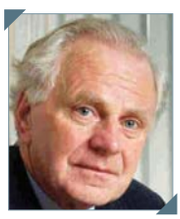
UCD Agri-Environmental Science students learning about the impact of agriculture on biological aspects of water quality.

New model of agriculture



Dr Liam Downey, Adjunct Professor, University College Dublin.
Dr Gordon Purvis, Senior Lecturer, Agriculture and Food Science Centre, University College Dublin.
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Dr Liam Downey and **Dr Gordon Purvis** (UCD) outline the implications of the model for 'Sustainably-Competitive Agriculture' for education, research, farmers and policy/decision-makers.

Development of the recently proposed model for 'Sustainably-Competitive Agriculture' (Purvis *et al.*, 2011) would make an important contribution to addressing the formidable array of challenges and uncertainties confronting the agri-food industry and, indeed, society in general, regarding food security, globalisation of food markets, climate change, environmental sustainability and the future economic viability of rural regions. As emphatically stated in a recent article published in Nature (Foley *et al.*, 2011), "The challenges facing agriculture today are unlike anything we have experienced before, and they require revolutionary approaches to solving food production and sustainability problems". The Sustainably-Competitive model provides a means by which these challenges can be addressed and an important framework for considering future strategic directions pertaining to: education, research, farmers and policy/decision-makers (Downey and Purvis, 2011). A number of overarching strategic initiatives in respect of these four important dimensions of development and innovation in agri-food systems are outlined in this article.

Education

With a view to shifting the mindsets of agriculturalists and farmers to 'think food', the development of a longer-term perspective in relation to future educational needs is a pressing requirement. In particular, priority needs to given to:

- **Removal of the traditional demarcation between disciplines.** In many current education systems the inherently interdependent domains of agriculture, food and environment are generally seen as discrete career paths, with separate educational provisions. Development of integrated agri-food education requires a fundamental reformation of the prevailing systems, including rationalisation of the roles of universities, institutes of technology and vocational education providers.
- **The harnessing of existing knowledge.** Much of the knowledge required for development of the Sustainably-Competitive concept already exists. The challenge is to harness the accumulating reservoir of relevant knowledge. In addition to the need for more effective knowledge management, translation and communication systems, incorporation of new knowledge into education programmes will require the active participation of those individuals and agencies engaged in its generation in the knowledge translation and education processes.
- **Continuing Professional Development (CPD).** The development of CPD courses and innovative, taught post-graduate (Masters) programmes will be essential in shifting current mindsets, towards the value-adding concept of sustainable competitiveness in agriculture and food.

Research

In formulating innovation-driven research programmes, priority needs to be given to:

- **Utilisation of the complex biological processes that underpin the functionality of agri-food systems.** This requires a fuller understanding of the benefits of functional biodiversity; in grass-based ruminant production, particular attention needs to be given to optimising the contribution of biological diversity to the processes of ruminant digestion and pasture productivity. The functionality of these inter-dependent epicentres of the model for sustainably-competitive livestock agriculture needs to be recognised as the primary focus of two thematic pillars of future research programmes.
- **Longer-term, systems-based research.** Innovative systems development needs to be supported by the concerted action of the relevant funding agencies, particularly in agriculture, food and environment. This will facilitate the necessary strategic framework for the development and integration of knowledge to achieve multiple, value-added (agronomic and environmental) benefits.
- **Recognition that knowledge management is critical.** Knowledge translation and integration, and communication processes, are an essential component for the planning and funding of future research investment.

Farmers

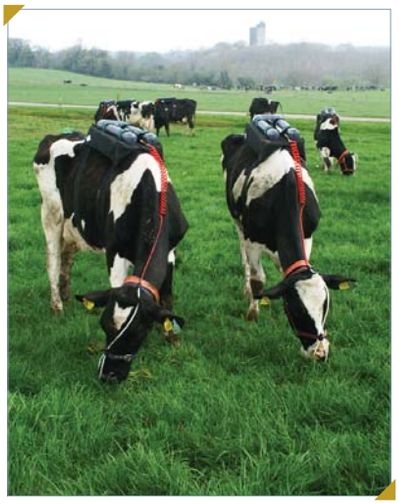
With their continued dependence on increasingly global commodity markets, farmers are essentially price-takers, and are vulnerable to fluctuating commodity prices. Development of the Sustainably-Competitive model would position agriculture in the middle ground, between industrialised and organic production systems. In this regard, priority needs to be given to:

- **Reduction in production-induced livestock disorders.** Such animal health and welfare issues tend to be largely a consequence of the increasing intensity of production systems, and can be extremely costly to producers. Throughout the global dairying industry, problems of infertility, acidosis, lameness, etc., could be reduced by the adoption of nutritional strategies that better match the genetic potential of livestock. Reduction of environmental impacts. In livestock systems, raising feed conversion efficiency by harnessing the evolutionary adaptations of ruminant digestion would alleviate gaseous emissions, while improving animal productivity. This will provide the potential to develop grass-based production systems with an enhanced capacity to cope with climate change.
- **Addressing product quality issues.** Reducing the variation in the quality and storage stability of dairy and beef products associated with seasonal production systems, would lead to more consistent product quality, and also reduce the scale of new capital investment in processing facilities.

Policy/decision-makers

Development of Sustainably-Competitive agriculture will require the following policy initiatives:

- **The creation of new organisational structures.** These need to involve public-private partnerships, including funding agencies, research, education and business organisations, and crucially, producers, processors, marketing, retailer and consumer interests.
- **Provision of dedicated public good funding systems.** Of paramount importance in this regard is the deployment of an appropriate proportion of the budget of the Common Agricultural Policy (CAP) to the development of the value-adding concept of Sustainably-Competitive agri-food systems.
- **Increased resources for extension and education services.** These need to be designed to ensure cost-effective knowledge translation, communication and assimilation, with particular regard to the education of the next generation of agriculturalists, farmers and food processors. In this process, it is essential that the growing concern noted over recent decades regarding the imbalance in research relative to knowledge translation and education is addressed.



Research is ongoing into the mininisation of ruminant greenhouse gas emissions.

The way forward for Ireland

Global competition, based exclusively on the price-competitive model, combined with climate change, is likely to exacerbate many of the concerns relating to a potential food crisis, animal health and welfare, the environment and energy supplies. The concept of sustainable competitiveness addresses a wide range of these major concerns and would facilitate the development of systems of valued-added gain for all involved, including producers, processors and consumers. Strategically-targeted research to support systems development, effective knowledge translation and education will be key determinants of the competitiveness and sustainability of the Irish agri-food sector and rural economies in the immediate decades ahead. Public good concerns relate to such crucial strategic areas as policy formation, climate change, energy supply, food safety and wider environmental concerns. Agriculture, like other natural resource-based industries, is critically dependent on concerted public good funding as the only realistic means to ensure effective support for longer-term systems development that addresses these areas. The value-adding strategy of Sustainable Competitiveness can therefore only be achieved by the development of a CAP-based Public Good funding system dedicated to guiding and supporting public-private partnership in the transition of agriculture from the predominantly production/output focus of former EU Common Agricultural Policy to more consumer/society-orientated multi-functional models.

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(Left page, clockwise from left) Niall Flynn, Colaiste Mhuire, Ballygar with some of the sheep on display; Dr John Finn talks to students from Loreto Secondary School, Wexford, about grassland mixtures and the nitrogen cycle, at the Science Week event held at Johnstown Castle Environment Research Centre.; Dr Dan Milbourne, Teagasc, Oak Park, Crops, Environment and Land Use Research Programme, talks to students from Carlow Institute of Technology about the potato breeding programme.

Science Week at Teagasc

Catriona Boyle, Scientific Writer/Editor, Research Support Team, Teagasc Head Office, Oak Park, Carlow. Correspondence: catriona.boyle@teagasc.ie

Teagasc supports Science Week by holding a series of events each year. The Forfás Discover Science and Engineering initiative aims to promote the relevance of science, engineering and technology in our everyday lives and to demonstrate the importance of these disciplines to the future development of Irish society and to the economy.

During Science Week, Teagasc research centres invited students from secondary level schools and third level colleges to see practical examples of the use of science in agriculture and food production. Over 1,000 people attended Teagasc's Science Week events.

Each year, the Teagasc Walsh Fellowships Seminar takes place in the RDS, Dublin, to provide a platform for the best young researchers to showcase the results of their research and to recognise the outstanding achievements of the best young scientists working in the agri-food areas.

The winner of the Teagasc Walsh Fellowships seminar and winner of the RDS medal was Sean Cummins, who presented a paper on 'The effect of genetic merit for fertility on reproductive efficiency' (see article on p16).

A President's medal from The Institute of Food Science and Technology Ireland (IFSTI) was presented to Eoin Murphy for the best food science and technology presentation. The subject of Eoin Murphy's presentation on 'Re-engineering infant formula manufacture' was an energy saving manufacturing process which, if implemented commercially, could

(Right page, clockwise from left) Dr Maria Hayes shows the students some extracts from seaweed and explains the Nutramara project; Pupils from Loretto School, Fermoy, being shown milk separation by Dr Brian Murray; Dr Fiona Thorne, Rural Economy and Development Programme, Teagasc, Dr William Reville, Associate Professor in Biochemistry in UCC and writer for ***The Irish Times*** science page, Dr Mark McGee, Research Directorate and Paul Maher, Knowledge Transfer Directorate, Teagasc, judged the oral presentations at the Walsh Fellowships Seminar.

have benefits for the economic and environmental sustainability of the infant formula industry in Ireland. Eoin is a Teagasc Walsh Fellow at the Teagasc Food Research Centre, Moorepark. His supervisors are Professor Yrjo H. Roos from UCC and John Tobin and Dr Mark Fenelon from Teagasc. The medal was presented by IFSTI council member Charles Lamb.

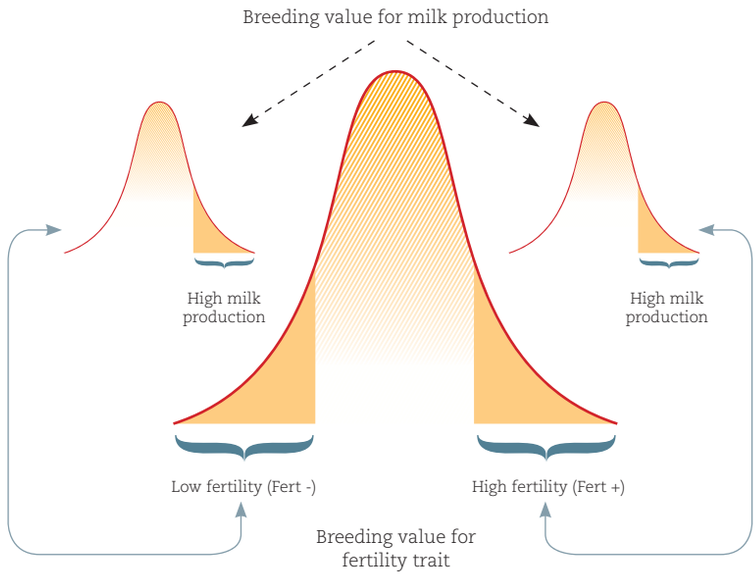
This year for the first time there was an award for the best three-minute presentation at the seminar and this was won by Gareth Burns for his presentation on 'Implementing quality parameters for ryegrass into a national variety evaluation scheme'. The output of this study allows the Department of Agriculture, Food and the Marine to routinely provide digestibility and water soluble carbohydrate information to Irish farmers through the annual recommended list publication. Gareth Burns is a Walsh Fellow at the Teagasc Animal and Grassland Research and Innovation Centre in Grange and at Queen's University Belfast. His supervisors are Dr Trevor Gilliland from the Agri Food and Bioscience Institute in County Down, Dermot Grogan from the Department of Agriculture, Food and the Marine (DAFM), and Dr Padraig O' Kiely, Teagasc.

The winner of the best poster was Joseph Lynch, for his poster on 'Manipulating the ensilage of maize conserved as whole crop, cob or stover,' (see article on p17).

Delivering the keynote address to the Walsh Fellowship seminar, Professor Maurice Boland, University College Dublin (UCD), said that Teagasc and UCD are at an advanced stage of agreeing a National Agricultural Research, Education and Innovation Partnership between the two organisations. "This will formalise and strengthen what is already being done and will build on the expertise and the amount of collaboration that is ongoing between UCD and Teagasc," he said.

Teagasc Director, Professor Gerry Boyle said: "Through the Walsh Fellowship scheme, both UCD and Teagasc have an interest in fourth level education, focused on innovation for the agri-food industry." He stressed the importance for all those working in the research space to have clear lines of communication into industry.

Well done to the Teagasc Science Week Committee and all those who participated in the events. For more on Science Week see: **www.scienceweek.ie**



Genetic merit for fertility on reproductive efficiency

Dr Sean Cummins and **Dr Stephen Butler**, Research Officer, Teagasc Moorepark, Animal and Grassland Research & Innovation Centre. Professors **Pat Lonergan** and **Alex Evans**, University College Dublin. Correspondence: stephen.butler@teagasc.ie

Sean Cummins was the recipient of the Best Oral Presentation at the Teagasc Walsh Fellowship seminar for his PhD on the effect of genetic merit for fertility on reproductive efficiency.

Reproductive biology is a field that has become increasingly important in light of the decline in dairy cow fertility performance over the last half century. Much of the decline in fertility has been attributed to the widespread use of genetic selection programmes that focused solely on increasing milk production until the turn of this century. In 2001, the Economic Breeding Index (EBI) was introduced in Ireland, allowing the incorporation of fertility traits for the first time. Since its introduction, the EBI has evolved to include six sub-indexes (relative emphasis in parenthesis): milk production (38.1%), fertility/survival (34.8%), calving performance (10.3%), beef carcase (7.2%), maintenance (6.1%) and health (3.6%) (http://www.icbf.com). The fertility subindex is comprised of two traits; calving interval (23.2%) and survival (11.5%). Despite intensive efforts in research institutes and universities across the globe, the precise mechanisms responsible for the decline in dairy cow fertility remain poorly understood. To elucidate the underlying physiological basis of declining reproductive performance, Sean carried out novel research to compare the phenotypic performance of Holstein cows with similar genetic merit for milk production traits, but with divergent genetic merit for fertility traits.

Within the Irish national herd, these animals were representative of the top quartile in genetic merit for milk production. However, the cows with good genetic merit for fertility traits (Fert+) represented the top 20% for calving interval, whereas the cows with poor genetic merit for fertility traits (Fert-) represented the bottom 5% for calving interval, respectively.

The two groups of cows were maintained as one herd throughout the study, thus standardising factors that are known to impact fertility performance (herd management, plane of nutrition, proportion of Holstein genes and genetic merit for milk production traits). The results clearly indicated Fert+ cows had improved reproductive performance during the breeding season, maintained greater body condition score (i.e., more body reserves) and had greater circulating concentrations of the key metabolic hormones insulin and insulin-like growth factor-1 (IGF-1) during lactation compared with Fert- cows. The research also identified orchestrated changes in the expression of specific genes in liver tissue during the gestation-lactation cycle to facilitate greater circulating (IGF-1) concentrations in Fert+ cows.

Following ovulation, a corpus luteum is formed on the ovary. This corpus luteum is responsible for production of progesterone, a steroid hormone that has long been recognised as 'the hormone of pregnancy'. After ovulation, Fert+ cows developed a corpus luteum that was 16% larger than those in Fert- cows, and blood concentrations of progesterone were 25% greater in Fert+ cows compared with Fert- cows. Interestingly, more Fert- cows ovulated without showing any behavioural signs of heat compared with Fert+ cows, and more Fert- cows failed to ovulate after displaying signs of behavioural heat compared with Fert+ cows. It is likely that these differences represent key mechanisms responsible for subfertility in the Fert- cows.

The findings from Sean's thesis clearly indicate that superior reproductive performance in Fert+ cows arose as a result of more favourable blood indicators of metabolic status, better oestrus expression and likelihood of ovulation at the appropriate time, and greater circulating concentrations of progesterone during early embryo development. This unique research has highlighted the large effects that genetic merit for fertility traits have on the physiological controls regulating reproductive performance, which may not necessarily be to the detriment of milk production. This unique herd represents a powerful animal model for future fertility research.

This research was funded by the National Development Plan and the Dairy Levy Trust.

Improving forage maize production in Ireland

Joe Lynch won best poster at the Teagasc Walsh Fellowships seminar for his work on improving forage maize production.

Joe Lynch and Dr Padraig O'Kiely,
Research Scientist, Teagasc, Grange, Animal and Grassland Research & Innovation Centre.
Dr Evelyn Doyle,
Senior Lecturer, School of Biology and Environmental and Science, UCD.
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Despite technologies such as plastic mulch facilitating the growth of maize in Ireland, further improvements in the crop production are required.

Including maize silage as a component of ruminant diets can promote high animal performance. The use of this feedstuff in Ireland has increased substantially during the past 20 years due to the development of new technologies such as early-maturing cultivars and plastic mulch. These facilitate the production of acceptable yields of a good quality ruminant feed, despite frequently unfavourable climatic conditions for maize growth. Notwithstanding this, the area of land in the Republic of Ireland growing maize has not increased above approximately 20,500 ha (2% of total grass silage area, 0.5% of total farmed land) since 2006. This recent cessation of expansion in the area used for maize reflects the high risk associated with growing this crop, and in particular the high annual variation in the dry matter (DM) yield and nutritive value of the forage. Thus, recent research conducted at Teagasc, Grange, Animal and Grassland Research & Innovation Centre investigated methods that may improve the yield and feed value of maize silage produced in Ireland.

Crop management

Cultivar and harvest date selection are major considerations in whole-crop forage maize production, and are typically based on estimations of the expected digestibility, starch and DM concentrations and DM yield of the forage at harvest time. Studies conducted during this project support the consensus that selecting an optimal harvest date for whole-crop maize involves a balance between starch content and fibre digestibility. Furthermore, results indicated that the impact that the subsequent ensilage of this herbage has on the yield and feed value of the silage should be a consideration in cultivar and harvest date selection. Substantial losses of highly digestible substrate can occur during the ensiling process due to effluent production or gas release during extensive silage fermentation.

In addition, these studies indicated that high nitrogen (N) application (>160 kg N/ha) on soils that are typically fertile, such as fields which had previously been in long-term permanent pasture, does not necessarily result in an increase of the grain proportion in the whole-crop, and thus can represent a waste of resources in the forage production system. Therefore, N application rates should be based on site specific estimations, rather than the maximum application allowed by legislation, in order to reduce unrewarded expensive inputs in the total maize silage production system.

Aerobic deterioration

Aerobic deterioration of maize silage is a major source of nutrient loss during feedout. This process is usually initiated by yeast, and inhibiting their activity can greatly extend the duration of aerobic stability. The addition of lactic acid bacteria (LAB), with the ability to produce compounds that inhibit yeast activity, to herbages at ensilage is one method of improving their aerobic stability. However, a study that evaluated the addition of *Lactobacillus buchneri* or *Lactobacillus plantarum* to maize observed no effect due to the indigenous wild-type LAB dominating in the latter stages of ensilage, producing anti-fungal compounds and rendering all silages aerobically stable. Therefore, the use of silage additives for maize production may be unnecessary on some farms, dependent on the indigenous microflora present on these crops.

White-rot fungi

Lignin-degrading white-rot fungi are commonly used to increase the digestibility and feed value of lignocellulosic crop residues. As the stover component of maize (i.e., stem, leaves, tassel, etc.) typically has a low feed value, an improvement in its digestibility would increase the overall efficiency of the maize production system. Therefore, we investigated the effect of pre-digestion of maize stover by white rot fungi (*Pleurotus ostreatus* and *Trametes versicolor*) on its digestibility. Although lignin degradation was observed, the substantial degradation of other more digestible components, such as hemicellulose and cellulose, also occurred. Thus, the digestion of stover by white-rot fungi did not incur an overall improvement in the digestibility of the stover.

Funding provided under the National Development Plan, through the Research Stimulus Fund administered by the Department of Agriculture, Food & the Marine.

Reaping what we sow

Eighteen students are currently carrying out PhDs under Teagasc's Walsh Fellowship Programme and seven post doctoral researchers are at the Rural Economy and Development Programme. **Dr Cathal O'Donoghue** follows the careers of alumni from the Rural Economy and Development Programme.

Dr Cathal O'Donoghue is Head of Teagasc's Rural Economy and Development Programme. Correspondence: Cathal.ODonoghue@teagasc.ie

As one of the most significant research organisations in the state, Teagasc's mission is to support the agri-food sector via research, education and knowledge transfer. However, it also plays an important role in inputting more directly to the research capacity of the country outside the organisation, both in institutions directly focused on the agri-food sector, but also in many other sectors. Indirect gains from public expenditure on research, via improved human capacity across industry, and the economy more generally, complement the direct effects generated within the sector Teagasc serves.

Teagasc is both an undertaker of research, competing for external research funding, and a funder of research via its Walsh Fellowship programme. Indeed, when the Walsh Fellowship programme was founded in the 1990s, Teagasc was one of the few national funders of PhD students at that time. In this article the employment destinations of the former students on the Walsh Fellowship Programme and former staff members employed by Teagasc on contracts funded by publicly funded competitive research programmes are analysed, classified as Teagasc Alumni in this article.

Where are they now?

In the autumn of 2011, a desk exercise was undertaken, assessing the destinations of these alumni. Although the desk exercise is not universal in that it was not possible to track all alumni, the analysis is relatively comprehensive. The largest destination of alumni is in industry with 32 of the total. Twenty-two currently have research positions, with 18 holding university lectureships and the remaining 14 holding positions more widely in the public sector.

A particular feature is the high success rate that alumni have had in being able to continue analytical careers complementary to their studies and research. In the last five years, despite the economic downturn, alumni from the Rural Economy and Development Programme (REDP) have close to a 100% employment rate in relevant areas, in general moving to a new position immediately after finishing with Teagasc.

The Walsh Fellowship Programme in particular facilitates collaborative research between Teagasc and partners in universities. University College Cork (12) has the highest number of graduates reflecting in particular, close links with the Food Marketing team. The second highest proportion of graduates (9) comes from National University of Ireland Galway (NUIG), reflecting the close location to our campus in Athenry. The remainder are from Dublin City University, Queen's University Belfast (QUB), University of Ulster, NUI Maynooth, University of Leeds, Dublin Institute of Technology, Trinity College Dublin (TCD) and University College Dublin (UCD).

Working in industry

The large numbers of alumni from the programme working in industry highlights how public research expenditure can facilitate capacity building within Irish industry. The vast majority work in Ireland or for Irish companies. About two thirds of those working in industry come from the Food Marketing sub-programme, working for organisations such as the Irish Business and Employers Confederation (IBEC), Alltech, the Irish Exporters Association, and a range of food businesses. In addition to marketing roles within industry, Teagasc REDP alumni have achieved quite notable roles as economists including as Executive Director at Goldman-Sachs, Chief Economists at IBEC and at the National Irish Bank.

Academic careers

Teagasc alumni have also been very successful in pursuing university academic careers, continuing to add to research output in the sector, as well as transferring knowledge to students. In recent years a very high proportion of economics lectureships in Ireland have gone to former Teagasc research staff and students in TCD, UCD, University of Limerick, QUB and NUIG and, internationally, in York and Macau. In other disciplines, alumni have lectureships in

Geography in the University of Liverpool and QUB and in Soil Science Modelling in Palermo. A number of alumni also work in the Institutes of Technology, including Dublin and Cork Institutes of Technology.

In addition to third-level teaching posts, Teagasc makes a substantial contribution to the economic research landscape; at the Economic and Social Research Institute and internationally at the European Commission's Joint Research Centre in Seville, the École Polytechnique Fédérale de Lausanne in Switzerland and at the University of New South Wales in Australia. Teagasc itself has been a significant beneficiary with 13 of our alumni moving from PhDs to post-doctoral positions in Teagasc at some point in their career, before moving to other roles elsewhere in the economy. The research department of the Central Bank of Ireland has been one of the biggest employers of Teagasc alumni, with five working there, many now with senior positions. Developing similar capacity for the Marine sector as for the Agri-Food sector, Teagasc alumni have established the Socio-Economics of Marine Research Unit at NUIG.

Economic development agencies have been another significant employer of alumni, including roles in local development companies as high as Chief Executive Officer, as well as State Agencies such as the Industrial Development Authority, FÁS (now SOLAS) and Bord Bia. REDP alumni have also taken roles more widely in the public service, including the Food Safety Authority of Ireland, and various government departments such as the Department of Environment, Heritage and Local Government, the Central Statistics Office and at the Department of Agriculture, Food and the Marine.

Skill set

What are skills that enable REDP alumni to be so successful? Working on targeted applied research questions of relevance to the sector within teams with a high focus on disseminating results to relevant stakeholders develops specific analytical skills, as well as more generic teamwork and communication skills amongst research staff and students. These skills are highly transferable, making our alumni of value in many different roles across the Irish economy and internationally.

Teagasc itself benefits significantly from its wider alumni network; frequently drawing upon our alumni as contributors to Teagasc national conferences, for example Fergal O'Brien from IBEC at the 2012 Outlook Conference made an excellent presentation on the macro-economic outlook. Many of our alumni working in the University sector now act as co-supervisors to our PhD students, continuing the collaborations started when they themselves were students. This collaboration also extends to partnership on funding proposals to various research funding agencies.

For more on the Walsh Fellowships scheme and current opportunities see: **http://www.teagasc.ie/research/postgrad/**

Profile: **Catriona Duffy**

Catriona commenced her PhD in 2009 looking at the impacts of climate change on the incidence of agriculturally important pests and diseases in Ireland. Her research interests are in natural and agricultural ecosystems and how they are impacted under environmental change. Her university supervisor at NUI, Maynooth, is Dr Rowan Fealy and her Teagasc supervisor is Réamonn Fealy from the Department of Agribusiness and Spatial Analysis, REDP.

Profile: **Stephen Hynes**

Stephen Hynes was a Teagasc Walsh fellow from 2001 to 2004 and subsequently spent three years as a Research Officer in Teagasc, working on model development and environmental economics. In 2008, he moved to NUI Galway as first director of the Socio-Economic Marine Research Unit. The unit has gained an international reputation for marine economic analysis, attracting over €3 million in external funding from both European and domestic funding sources and now has a complement of seven researchers and four PhD students. Stephen's main research interest is in microeconomic behaviour analysis and his work has been published by a number of the top ranked journals in these fields including *Ecological Economics*, *the American Journal of Agricultural Economics and Land Economics*. See **www.nuigalway.ie/semru/hynes.html** for further information.

Mid-infrared spectrometry is one tool currently being researched by Teagasc geneticists to capture more data for use in the national breeding programme.

Phenomics – the foundation of sustainable genetic gain

Dr Sinead McParland, Research Officer. **Dr Donagh Berry,** Principal Research Officer, Teagasc Animal and Grassland Research & Innovation Centre, Moorepark. Correspondence: Sinead.McParland @teagasc.ie

In the past decade, the amount of data recorded on the Irish Cattle Breeding Federation's national database has increased dramatically. This increase has been greatly boosted through new ways of recording data. In this article, we discuss the past, present and future research into collection of phenotypes for use in improving our national genetic evaluations of beef, sheep and dairy populations.

In the era of genomics, it is phenomics that still underpin genetic gain. As genomics is the study of the genome or DNA of an individual, phenomics is the study of the phenotypes or 'on-the-ground performance' of an individual. Access to large quantities of accurate and diverse phenotypes remains as important now in animal breeding as it was centuries ago when animal breeding was solely based on phenotypic selection. Simply increasing the accuracy of genetic selection by ten percentage units is worth €4 million, €2 million and €0.8 million annually to the Irish dairy, beef and sheep sectors, respectively. Increases greater than these have already been obtained in dairying based on research from Teagasc geneticists.

Traditional measures of performance

Traditionally in lactating animals the most important phenotype was milk production, and in growing animals it was daily gain. Until the early 2000s, milk recording was generally undertaken by milk recording technicians every four weeks. However, two published research projects undertaken by Teagasc geneticists proved that reducing the frequency of milk recording to every eight weeks was just as accurate as milk recording every four weeks, and that do-it-yourself milk recording was also accurate. This research can potentially reduce the cost of milk recording to 33% of its original cost. Today, over 49% of cows and 39% of herds in the national herd are milk recorded, whilst 33% of herds in milk recording operate the do-it-yourself system.

The growth of an animal pre-weaning is dictated by both the (genetic merit for) milk production of

the dam as well as the (genetics for) growth potential of the animal itself. Estimates of growth potential, as well as a proxy for milk yield, can be obtained from individual animal live-weight information pre-weaning. Yet, such data are lacking since live-weight data available is generally confined to the post-weaning period. However, recent research by Teagasc geneticists clearly identified significant genetic differences among animals for growth potential and for dam milk yield in Irish cattle when weighed around the period of weaning. Nonetheless, to correctly elucidate the dam milk yield from individual growth potential, serial measures of animal weight are required and capturing these data is the focus of on-going research by Teagasc and the Irish Cattle Breeding Federation.

Measures of functionality

In recent decades the contribution of sub-optimal fertility and survival to overall profitability has been highlighted in dairy, beef and sheep populations. The absence of such functional traits in most national breeding objectives was due primarily to a lack of data on these traits. Scandinavian countries were the exception and they have been selecting on functional traits in dairy populations for many decades now because of the strict requirement for recording in these countries.

Irish dairy and beef production systems operate seasonal calving making fertility a very important contributor to profitability in those enterprises. It is a legal requirement to record the birth-date and dam of newborn calves. Although initially implemented to improve animal traceability, individual cow calving dates also facilitate the estimation of calving interval, an important fertility trait for seasonal calving herds. Despite the perception amongst some, the recording of these data is accurate, although not as accurate as other objectively measured traits such as milk yield. If recording of fertility traits was not accurate, the significant genetic variation in fertility traits identified by Teagasc geneticists in dairy and beef cattle would not have been identified. However, the traits are lowly heritable meaning that relatively larger populations of animals are required to achieve the same reliability of genetic proofs compared to higher heritability traits such as milk yield. Health traits including mastitis and lameness events are also generally lowly heritable, as evidenced by recent Teagasc research using data recorded by farmers as well as data from Teagasc's Dairy Efficiency Programme.

The farmer knows best

One of the most eye-opening areas of research in recent years has been the quantification of the usefulness in genetic evaluations of data recorded by individual farmers on animal attributes. Joint research between Teagasc and the Irish Cattle Breeding Federation clearly shows a huge benefit in farmer-recorded traits in improving the accuracy of national genetic evaluations. In 2011, approximately two million calving events with associated records for the degree of calving assistance were recorded by Irish farmers. These data are used in the national genetic evaluations for calving difficulty and perinatal mortality in Ireland and are probably one of the largest data sources of calving performance in the world. As the heritability of these traits is consistent with international estimates, it suggests a high degree of accuracy of recording. This means more accurate estimates of genetic merit for calving difficulty on individual sires and, thereby, aiding in breeding decisions.

Other examples identified by Teagasc geneticists with industry collaborators was the ample exploitable genetic variation in traits scored by Irish farmers including docility, weaning quality, mastitis and lameness.

Phenomics of the future

The phenotypes of the future must be: 1) routinely measureable at a low cost, 2) exhibit genetic variation, and, 3) if only a predictor of the real phenotype of interest, they must be strongly genetically correlated with the phenotype of interest. Infrared technology is currently applied to all individual cow and bulk tank milk samples recorded nationally to predict milk fat, protein and lactose. However, recently published research undertaken by Teagasc geneticists with international collaborators clearly showed that this technology could also be used to predict milk fatty acid and lactoferrin content in milk, traits that are both economically important and are also correlated with fertility and mastitis, respectively. Similarly, it has been clearly shown by Teagasc geneticists that the mid-infrared spectrum of a milk sample can be used to predict energy intake and energy balance - another known indicator of health and fertility. The exploitation by industry of infrared analysis of milk to predict more traits forms part of several large international research projects to which Teagasc contribute.

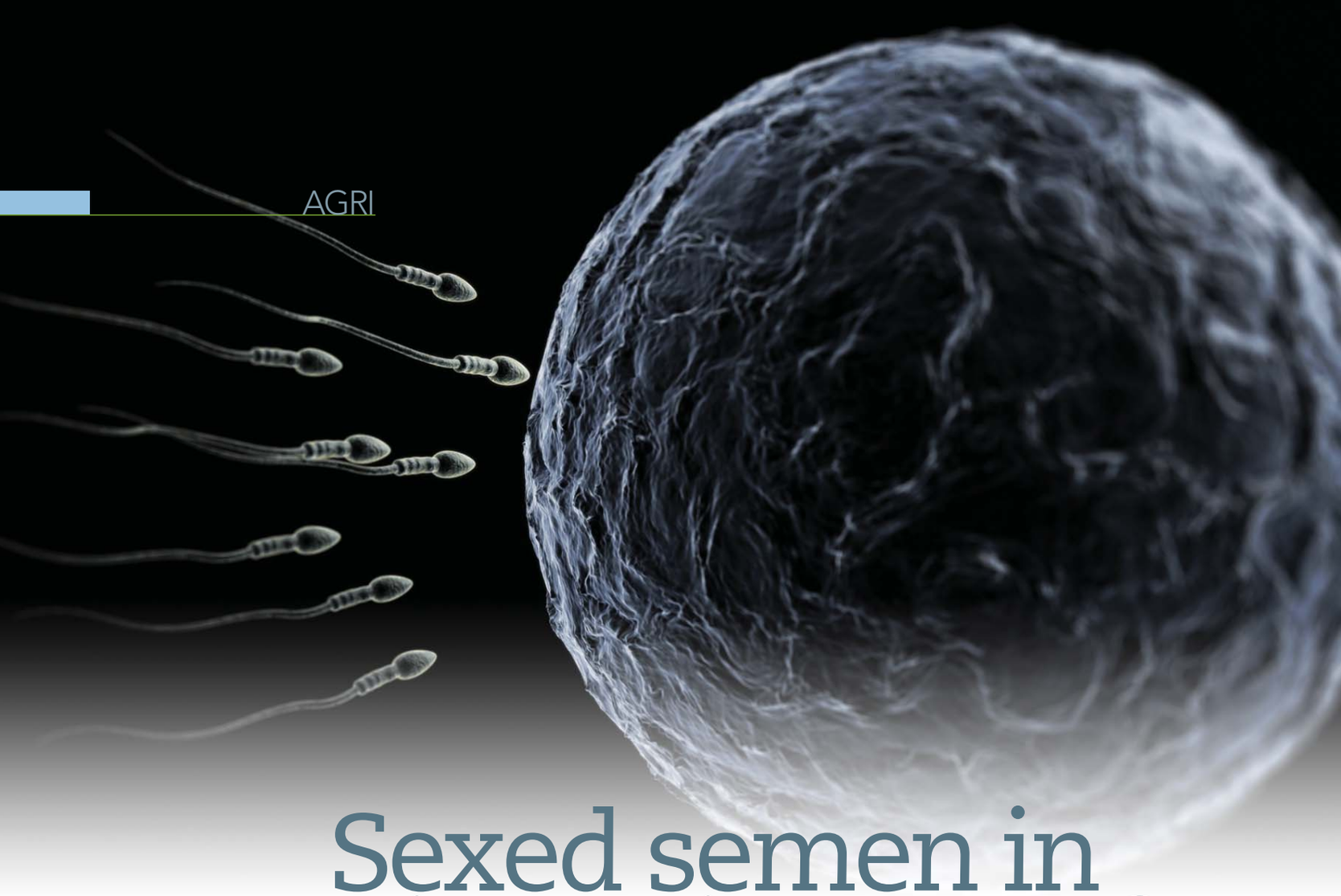
Using infrared technology to predict meat quality in beef and sheep is a growing area of interest within Teagasc in collaboration with other research institutes both in Ireland and internationally. The advantage of this approach is that, if successful, large populations of carcasses can be screened at a low cost for meat quality and accurate estimates of genetic merit for meat quality on individual bulls generated.

The benefit of using video image analysis of cattle carcass to apportion the carcasses into very high value cuts, high value cuts, medium value cuts, and lower value cuts; and to assess their genetic variation has been clearly shown by a recently completed Walsh Fellowship PhD in genetics; these traits will soon be included into national genetic evaluations to more accurately improve breeding decisions for higher value carcasses. Image analysis of reproductive tract scores and quantifying the genetic variation present in the health of the reproductive tract is a current area of research by Teagasc geneticists.

Monitoring response to selection on difficult to measure traits

Despite the large volume of research into increasing the quantity and type of data for our national genetic evaluations, some traits still remain unaccounted for. Traits such as feed intake and gas emissions cannot as yet be accurately accounted for in the national herd. With the rapid acceleration in genetic gain expected from new technologies including genomic selection, a new research herd, the Next Generation Research Herd is proposed to be established to monitor elite genetic merit animals maintained on futuristic Irish grass-based systems of production. The elite animals, the cows of tomorrow, will be used to investigate the impact of selection on difficult to measure traits such as feed intake, greenhouse gas emissions and health traits, to identify and, if necessary, rectify deleterious consequences of selection.

Projects mentioned in this article were financially supported by several research funding steams. These included the European Commission under the Seventh Research Framework Programme (RobustMilk), the INTERREG IVB North West Europe Programme (OptiMIR), Department of Agriculture, Food and the Marine Research Stimulus Fund, ERAD, and the ICBF.



Sexed semen in Irish dairy herds?

Is there a role for using sexed semen in Irish dairy herds? Teagasc researchers have been investigating its use to expand the Irish dairy herd.

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Background to sexed semen technology

The ability to select the sex of offspring at conception is one of the most sought after reproductive biotechnologies of all time. Female dairy offspring are more desirable than male offspring, particularly with the impending removal of the milk quota regime. The opposite is true for beef cattle, where male offspring command a price premium over female offspring. Semen contains sperm containing approximately equal numbers of X or Y chromosomes, resulting in female or male offspring, respectively (females have two X chromosomes and males have one X and one Y chromosome). A major breakthrough came when it was observed that sperm containing X chromosomes contain more DNA (about 4%) than sperm containing Y chromosomes. This means that if sperm could be sorted on the basis of DNA content, it would be feasible to generate semen for artificial insemination that is specifically enriched with sperm containing either X or Y chromosomes only.

Flow cytometry is a technique routinely used to count and examine cells, and can be adapted to purify particular cells of interest based on a property that distinguishes one type of cell from another type of cell. Fluorescence-Activated Cell Sorting (FACS) is one specialised type of flow cytometry, and is the most reliable and widely used technique to sort sperm containing X or Y chromosomes based on differences in total amount of DNA contained in sperm cells. Sorting bovine sperm by flow cytometry is approximately 90% accurate.

Challenges and limitations of flow cytometry to sort semen

The primary limitations of using flow cytometry to sort semen are: (i) the slow speed of the process relative to the number of viable sperm required for artificial insemination in cattle; and (ii) the high proportion of sperm cells that are lost, cannot be oriented for sorting, or cannot be accurately identified as bearing an X or Y chromosome and pass through without being sorted (combined >75% loss). Of the remainder that are successfully sorted, only half are the desired gender. Consequently, only 10 to 15% of the original sperm population entering the flow cytometer are recovered as marketable sexed semen. Conventional semen straws contain approximately 20 million sperm. Sorting speeds are currently

Figure 1a

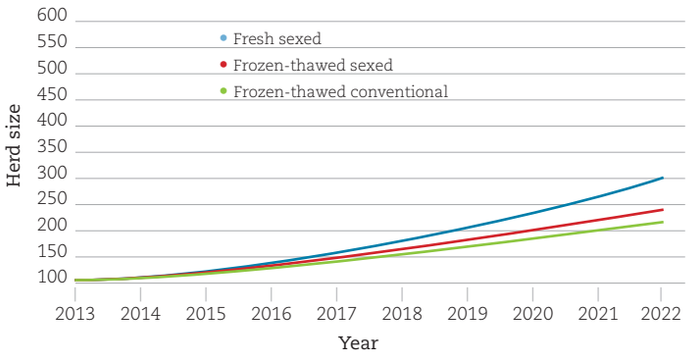


Figure 1b

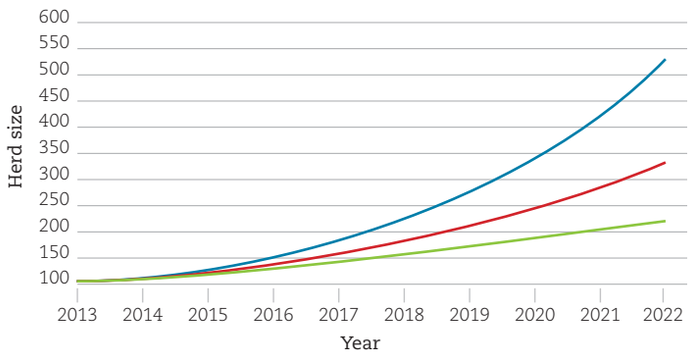


Figure 1: A theoretical scenario demonstrating the potential rates of herd expansion when using either fresh sexed semen, frozen-thawed sexed semen or conventional frozen-thawed semen.
Figure 1a: Different semen products used at first and second service in maiden heifers only. Figure 1b: Different semen products used at first and second service in maiden heifers and lactating cows during the first six weeks of the breeding season.

inadequate for commercially viable production of semen straws containing 20 million sperm and, consequently, sexed semen straws generally contain approximately 2 million sperm. As a result of both sperm damage during the sorting process and lower sperm numbers included in each straw, use of sexed semen generally results in poorer conception rates compared with conventional semen. Data from recently published studies conducted in the USA, Denmark, Switzerland and China indicate that conception rates achieved with frozen-thawed sexed semen in maiden heifers are approximately 75% of those achieved with conventional semen (e.g., conception rate of 70% for conventional semen vs. 52.5% for sexed semen). The reduction in fertility observed when using sexed semen has, to date, restricted its use to inseminations on maiden heifers. Preliminary results from New Zealand suggest that using fresh sexed semen results in conception rates that are 90 to 95% of those achieved with conventional frozen-thawed semen in both heifers and lactating cows. Avoiding the sperm damage and mortality associated with the freeze-thaw process has beneficial implications for fertility performance, and has important implications for sexed semen use in seasonal-calving systems, such as in Ireland.

Sexed semen in the Irish dairy industry

The principal benefit of using sexed semen in the Irish dairy industry is increased numbers of heifer calves born, with approximately 90% of successful pregnancies resulting in a heifer calf. The subsequent increased availability of replacement heifers could form a pivotal component of the 50% increase in milk output targeted in *Food Harvest 2020*, the Department of Agriculture, Food and the Marine's strategy for Irish agriculture. Figure 1 illustrates the potential increase in rate of herd expansion when either frozen-thawed sexed semen or fresh sexed semen is used compared with conventional frozen-thawed semen. In Figure 1a, sexed semen is used only on maiden heifers, for the first and second service. Conception rates in heifers are assumed to be 70% for conventional frozen-thawed semen, 66% for fresh sexed semen and 53% for frozen-thawed sexed semen.

In Figure 1b, sexed semen is used on heifers and also on lactating cows inseminated in the first six weeks of the breeding season. Conception rates in lactating cows are assumed to be 50%, 47% and 38% for conventional frozen-thawed, fresh sexed and frozen-thawed sexed semen, respectively.

In the first two years of the simulation (2013 and 2014), 20 replacement heifers were retained to maintain a herd size of 100 cows. Thereafter, all available heifers were retained to facilitate herd expansion. Mating start date is assumed to be April 25 every year. Mean herd calving dates every year are March 1 for both conventional frozen-thawed semen and fresh sexed semen and March 2 for frozen-thawed sexed semen when only maiden heifers are inseminated with sexed semen. When sexed semen use is extended to include lactating cows, mean herd calving dates are March 1, 2 and 7 for conventional frozen-thawed, fresh sexed and frozen-thawed sexed semen, respectively.

In addition to the projected increased rate of herd expansion, use of sexed semen may also have beneficial effects in other ways:

- Reduced incidence of calving difficulty (heifer calves are smaller than male calves).
- Improved biosecurity by allowing farmers to increase herd size while maintaining a closed herd.
- Reduced numbers of low-value male dairy calves born.
- Use of Y-chromosome bearing sperm (i.e., male offspring) from easy-calving beef bulls after the first six weeks of breeding to generate higher value male calves for beef.

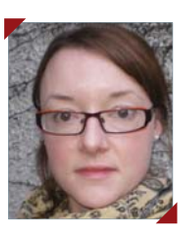
Future research and commercial implementation

Research is currently being undertaken to model the economic impact of using sexed semen in heifers and lactating cows on Irish dairy farms. As sexed semen is more expensive than conventional semen (€12 to €20 more per straw) and fertility performance will likely be poorer, it is important to assess the benefits of increasing numbers of heifer calves against the increased costs and potential detrimental effects on calving pattern. Initial observations suggest that use of sexed semen could have important implications for the rate of national herd expansion after the quota regime is removed.

This research is funded by the National Development Plan, the Dairy Levy Trust Fund and the Teagasc Post-Doctoral Fellowship Scheme.

Acquisition of sufficient immunoglobulins from colostrum immediately after birth is the single most important factor in ensuring the health and productivity of the calf.

Making the most of colostrum



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Muireann Conneely and **Dr Emer Kennedy** have been working on quantifying the quality of Irish dairy cow colostrum in order to improve calf survival rates.

Colostrum (or biestings) is defined as the milk produced at the first milking post-calving and contains a host of vital immunological and nutritional substances that are crucial to ensure the health of the newborn calf. Most important of these are the immunoglobulins, cells of the immune system that protect the newborn calf from the environmental pathogens it will encounter as soon as it is born. The bovine placenta does not allow the transfer of immunoglobulins from the mother to the calf while the calf is *in utero*: the calf is born with no circulating immunoglobulins, and depends entirely on colostrum to provide it with immunological protection.

Without adequate immunological protection, the newborn calf is more vulnerable to infection, more likely to develop disease and die in the pre- and post-weaning periods, has a slower growth rate and even reduced milk production during the first and second lactation. Acquisition of sufficient immunoglobulins from colostrum immediately after birth is the single most important factor in ensuring the health and productivity of the calf.

Calf health

A Policy Delphi survey of both farmers and experts carried out by Animal Health Ireland identified calf health as a priority area that needs to be addressed. The Irish calf mortality rate is approximately 9% (DAFF, 2010) within the first 12 months of life; nearly three times the target of no more than 3% outlined in the literature.

A recent Irish Cattle Breeding Federation statistic (personal communication) revealed that only 48% of heifer calves born in 2007 calved down in 2009 at the target age of between 22 and 26 months. Seventy-one per cent of neonatal calves submitted to Regional Veterinary Laboratories for post-mortem in 2010 were reported to have inadequate absorption of immunoglobulins (AFBI/DAFF, 2010).

This data clearly indicates that there is a need to improve calf husbandry practices and increase the number of maiden heifers entering the dairy herd in a timely manner. This is even more critical given the impending abolition of milk quotas and the consequent rise in calf numbers expected. Now, more than ever, efficient colostrum management programmes are crucial to ensure the health and productivity of these calves. Two studies, carried out in the Moorepark Animal and Grassland Research & Innovation Centre between January and April 2011, have sought to address some of the issues surrounding colostrum quality and feeding to newborn calves.

Colostrum quality in Irish dairy cows

The concentration of immunoglobulin G (IgG) in the colostrum determines its quality; the higher the IgG concentration, the better the quality. Colostrum contains a wide spectrum of important immune and nutritional components. However, since IgG composes more than 85% of total Ig in colostrum, the concentration of IgG in colostrum has traditionally been the hallmark for evaluating colostrum quality. High quality colostrum has an IgG concentration greater than 50mg/ml (McGuirk *et al*., 2004).

Provision of good quality colostrum is a fundamental part of an efficient colostrum management programme. Currently, however, there is a lack of published data on the colostrum quality of Irish dairy cows. Furthermore, few studies have examined the factors associated with the colostrum quality of cows in seasonal, grass-based systems such as those that exist in Ireland. The objective of this study was to determine the factors associated with the IgG concentration in the colostrum of Irish dairy cows. This information will enable farmers to maximise the efficiency of their colostrum management programmes and, ultimately, improve calf health across the Irish national herd.

Colostrum quality study

Fresh colostrum samples were collected from 642 spring-calving dairy cows of varying breed and parity. Each cow was milked by machine at the next scheduled herd milking time following calving. Colostrum was collected, the weight was recorded and a sample of colostrum was obtained and frozen until analysis. The IgG concentration was determined using an ELISA method. Information recorded from the cows included: time and date of birth, sex, weight and breed of the calf, presentation of the calf, degree of calving difficulty, time interval from calving to subsequent milking, cow body weight measured up to 14 days post-calving and body condition score measured within 14 days of calving, length of dry period, cow Economic Breeding Index, breed fraction, and degree of heterosis and recombination. These factors were statistically analysed to determine which were associated with colostrum IgG concentration.

The results of the experiment showed that the quality of the colostrum varied greatly. The average IgG concentration was 112 mg/ml, with a range of 13 to 257 mg/ml. In total, almost 96% of the samples were classified as high quality colostrum (>50mg/ml). Cows in later lactations produced colostrum with higher IgG concentration than those in earlier lactations even after adjustment for differences in milk yield at the time of milking. The highest quality colostrum was obtained from cows in their fifth lactation.

IgG concentration increased as time interval from calving to milking decreased which implies that colostrum should be collected from the cow as soon as possible post-calving in order to maximise colostral IgG concentration.

Length of the dry period was also associated with the quality of colostrum; quality was lower when the dry period was less than eight weeks and greater than 16 weeks thus having a dry period between 8 and 16 weeks appears to improve colostrum quality.

In general, higher yielding cows also tended to have poorer quality colostrum due to dilution of colostrum IgG concentration. IgG concentration decreased by 1.19 mg/ml per kilogramme increase in the colostrum yield.

Changes in IgG over first six milkings

The milk produced by the cow for a number of days post-calving has a higher IgG content than whole milk. However, it may be insufficiently high to provide adequate IgG for absorption by the newborn calf and, as such, may not be suitable for feeding at the first feed following birth. The objective of this second study was to quantify the change in colostrum IgG concentration with each successive milking post-calving up to the sixth milking. This information will provide knowledge on the persistence of IgG levels post-calving, to clarify which milkings post-calving are suitable for feeding at the first feed.

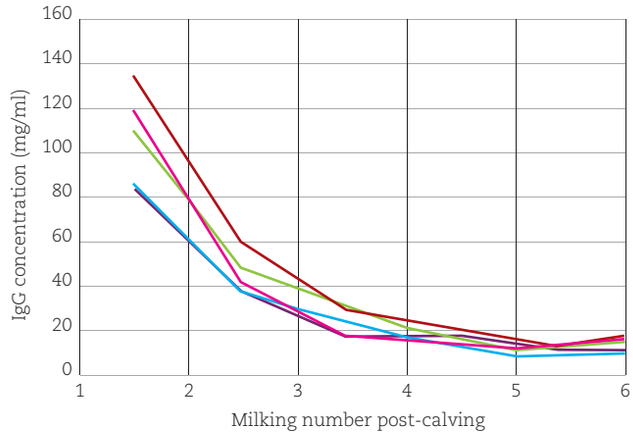

Figure 1. IgG levels for the first six milkings post-calving for parity 1 (blue), 2 (pink), 3 (green), 4 (turquoise) and 5+ (red).

Colostrum samples were collected from 98 Holstein-Friesian dairy cows: 20 cows of first, second, third, and fourth parity and 18 cows of fifth or greater parity. Post-calving, each cow was milked at the next standard herd milking time and samples were taken for the first six milkings post-calving. Colostrum samples were collected and analysed for IgG concentration in the same manner as for the study above.

This study found that older parity cows produced colostrum with a higher IgG concentration at the first milking. For all parities, IgG concentration in milk declined rapidly with each successive milking post-calving (Figure 1): the concentration at least halved between first and second milking. Only the colostrum from the first milking had an IgG concentration above the threshold of 50mg/ml IgG. This study highlights the importance of using only the colostrum obtained at the first milking as a source of colostrum for newborn calves regardless of which parity the cow is.

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This research was funded by Teagasc core funding and the Teagasc Walsh Fellowship Scheme.

Putting nutrients on the map

Teagasc environment researchers outline how a novel prototype geo-computational information management system arising from the Agricultural Catchments Programme is being used to better manage farm nutrients.

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The nutrient challenge

In Ireland, the Department of Agriculture, Food and the Marine's ambitious *Food Harvest 2020* targets for agricultural production will lead to greater demand for nutrient inputs and better nutrient management on farms as production intensifies. Nutrient management will be particularly important on dairy and beef farms where higher quantities of organic manure will be produced and will need to be balanced with chemical fertilisers to achieve high levels of nutrient utilisation efficiency. How can this be balanced with the needs of environmental protection?

Towards greater efficiency

Using nutrients efficiently is critical for profitable and sustainable farm production. Farm fertiliser planning for nitrogen (N) and phosphorus (P) is also mandatory under the EU Nitrates Directive rules, which constrain N and P fertiliser applications on farms. Alongside these legislative constraints, the cost of fertiliser has increased continuously in Ireland since 2000, forcing farmers to re-evaluate their fertiliser input strategies in order to optimise fertiliser usage. To facilitate increased fertiliser use efficiency on farms, the development and use of a farm nutrient management plan (NMP) is one strategy for maximising the return from on- and off-farm nutrient resources, and has the potential to yield a double-dividend by also reducing the risk to the quality of nearby water and reducing greenhouse gas emissions.

Nutrient management planning

To date, developing an NMP for a farm has often been seen as a cumbersome task, requiring the collection of data from a number of disparate sources, and resulting in complicated and lengthy spreadsheet outputs. The NMP output is often complicated and poses difficulties for routine consultation and decision making prior to conducting day-to-day tasks. The Agricultural Catchments Programme (ACP) (Fealy *et al.*, 2010) has developed a novel prototype geo-computational information management system to collate and manipulate multiple farm nutrient source and geospatial data sets. Currently, the ACP is using this technology to facilitate better farm nutrient management planning in six catchments, each comprising of between 35 to 80 farms (Wall *et al.*, 2011). This novel automated system not only offers a farmer a conventional NMP but, also, the facility to

Figure 1: Colour-coded spatial representation of soil test phosphorus (P) indices for a farm. Also shown are the soil test P concentrations (Morgan's P) for each.

Figure 2: Crop and soil test specific phosphorus fertilizer and slurry application advice for a farm.

create a range of maps representing the numerical data outputted from these plans. These maps can be spatial representations of various field-specific information, such as soil test results (Figure 1), task based (such as nutrient application advice - Figure 2), record based (such as historic nutrient application quantities and timings, cropping histories and yields). They can also be report based, such as reporting on the efficacy of past nutrient management by displaying field nutrient balances (nutrient inputs less off-takes, i.e., nutrients taken up by the crop). This technology can be used to overlay many years of information, enabling farmers and advisors to track temporal changes in soil fertility and nutrient management.

Recording day–to-day farm practices

As this new technology/advice is implemented on farms, it is important to assess the levels of uptake, adoption and impacts on production and the environment. The ACP has developed a nutrient management recording facility to capture day-to-day farm management events (e.g., fertiliser applications) on farms that link to the farm nutrient data management system. These data are critical to evaluate the current nutrient management strategy and track progress on farms and to inform changes to the NMP by identifying inefficiencies by reviewing current or historic records.

Realising multiple benefits

Better farm nutrient management brings with it many production, economic and environmental benefits. Where nutrient inputs are better matched to crop off-take, higher levels of nutrient use efficiency can be realised. Better distribution of available nutrients across the farm, according to soil nutrient status and production targets, will potentially lead to cost saving on fertilisers and protect output levels over the entire farm. This in turn will potentially reduce the risk of nutrient losses to water bodies and to the atmosphere. Currently, ACP Advisors can conduct a nutrient management review for a farm, utilising multiple data sources in an efficient and informative way, using the farm nutrient data management system. The ACP Advisors have observed that the catchment farmers engage with the nutrient management information to a greater extent when presented spatially (on maps) for their farms and fields. They also have greater confidence that the nutrient management advice administered this way is carried out more accurately and in a more informed manner.

Future use and development

The comprehensive spatial dataset developed by the ACP has the potential to link to other databases including spatial datasets; for example, soil hydrological connectivity maps, land use maps, soil and geology maps, topographical and LiDAR maps, and habitat maps. In terms of on-farm nutrient management, this allows a geo-spatially integrated NMP plan to be developed including not only the traditional soil, fertiliser and crop aspects, but also the spatial identification of discrete areas of higher potential nutrient loss risk across the farm based on soils (Figure 3a) and hydrological connection (Figure 3b). This allows more detailed spatial interrogation of different data sources in combination for research and management purposes. It also provides greater opportunity for land managers and researchers, to utilise various data sets in a more meaningful and productive manner.

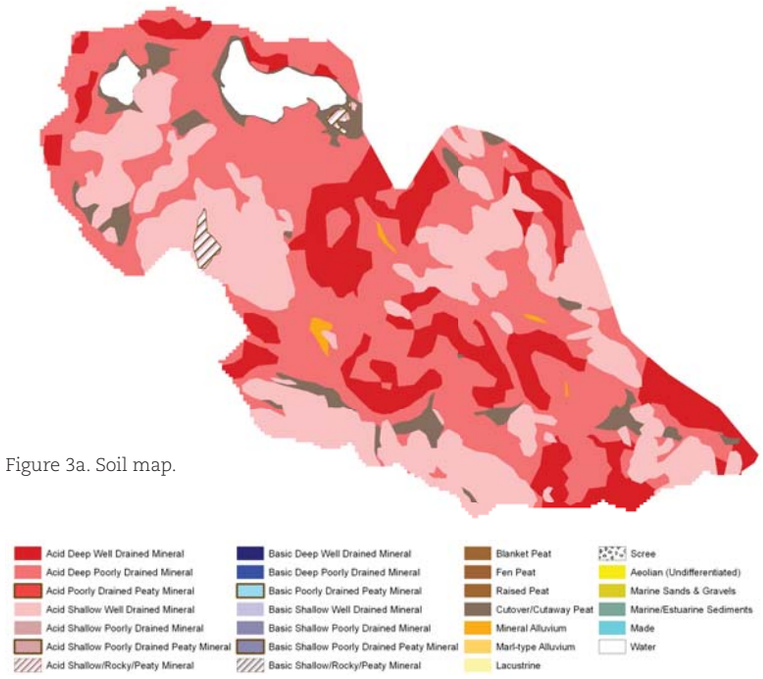

Figure 3a. Soil map.

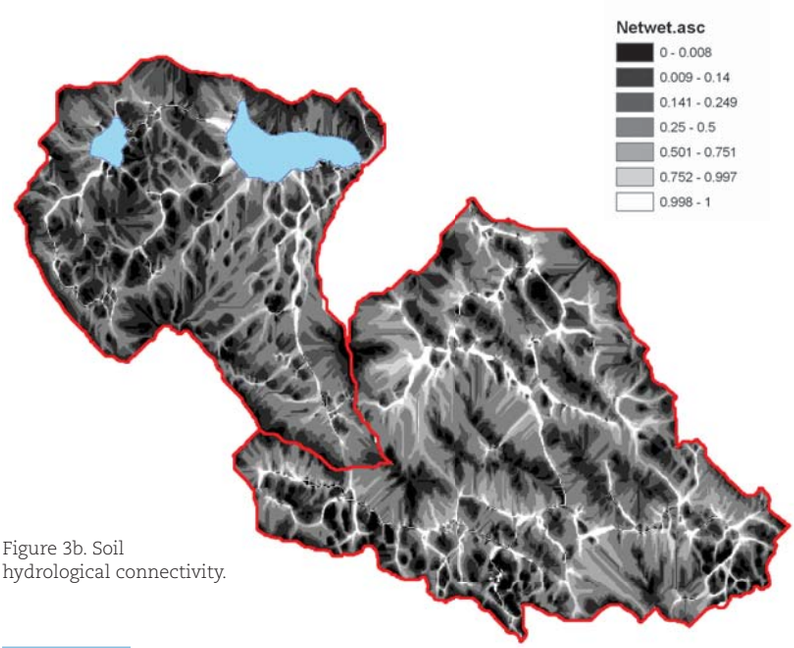

Figure 3b. Soil hydrological connectivity.

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Food Harvest 2020: a brighter shade of green?

A multi-disciplinary team of Teagasc researchers reports on a first assessment of the challenges and solutions to achieving sustainable growth in agriculture while meeting environmental targets.

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Green growth

Irish agriculture is entering a new growth era, with the removal of milk quota, the reform of the Common Agricultural Policy and the global increase in demand for food, particularly livestock produce. *Food Harvest 2020* (www.agriculture.gov.ie/agri-foodindustry/foodharvest2020/) outlines the industry's ambition to increase (among other targets) milk production by 50% and the value of beef products by 20%. This strategy gives a profoundly new role to the concept of environmental sustainability in Irish agriculture: it no longer considers this merely in the context of constraining agricultural production; instead, it puts sustainability at the heart of the strategy to deliver growth and added value to Irish produce. Indeed, at an international level, sustainability is now a key element of competitiveness and consumer expectations. Ireland is in a very strong starting position to capitalise on our green credentials, with Irish dairy products having the lowest carbon footprint in the EU and our proportion of 'clean' waters being fourth highest in the EU.

A deeper shade of green?

Notwithstanding this strong starting position, the environmental targets for agriculture will continue to become more stringent and more challenging, both at European and national level.

For example, sharp reductions in greenhouse gas emissions are to be expected from all sectors of the European economy and any future targets are likely to be challenging in view of the modest increase in total agricultural greenhouse gas emissions that has been projected for a *Food Harvest 2020* scenario, despite ongoing gains in carbon efficiency. Similar scenarios are unfolding in relation to reaching the stringent water quality targets demanded for high-status water bodies, such as those containing viable populations of the freshwater pearl mussel, and in relation to reaching future targets for the protection of farmland biodiversity and soil quality.

Supply and demand for land use functions

This juxtaposition of the agricultural growth strategy and the tightening of environment targets raises the question whether Irish agriculture can simultaneously meet *Food Harvest 2020* targets and future environmental targets. In other words - can we ensure that sustainability remains a key ingredient of the competitiveness of our producers?

To answer this question, a multi-disciplinary team of Teagasc researchers has conducted a preliminary analysis of the 'demand' and 'supply' of primary land use functions, i.e., the agricultural and environmental goods that society is asking agriculture to deliver. These are:

- Production of food, fibre and (bio)fuel
- Purification of water
- Sequestration of carbon
- Providing a habitat for biodiversity
- Recycling of (external) nutrients, such as sewage sludge and manure from intensive enterprises

While land use functions are not necessarily mutually exclusive, the question that emerges is: whether there is enough land in Ireland to provide all of these functions? To answer this question, our preliminary analysis has selected proxy-indicators for each of the five land functions (Table 1) and quantified whether the projected 'supply' of each of these indicators will meet the various projected legislative or policy 'demands'. For example, how much carbon

can be sequestered in our soils, and will this meet policy demands to reduce greenhouse gas emissions? Similarly, what nitrate loading can our soils denitrify and will this be sufficient to meet groundwater quality targets in a *Food Harvest 2020* scenario?

Our preliminary results (Table 1) show that, at national level, agricultural soils have the potential capacity to deliver on both *Food Harvest 2020* targets and on environmental targets. However, realising this potential will require a large degree of management, as significant challenges are likely to emerge at regional and local level. Whilst the average capacity of our soils to provide food, denitrify groundwater nitrates, support biodiversity, sequester carbon and recycle nutrients exceeds the projected national demand for these land use functions, large differences in this capacity are expected between soils and regions. For example, Table 1 shows that at local level, the livestock carrying capacity may range from 0.5 to 3.0 livestock units per hectare and the denitrification capacity from 5 to 63 kg nitrogen (N) per hectare.

Pathways to green growth

In summary, there is a realistic potential to achieve the growth targets of *Food Harvest 2020* and at the same time meet environmental targets, but only if these twin objectives are managed together from the outset. The nature of such management depends on the scenarios through which the targets will be delivered. The three most likely scenarios are:

Increasing production efficiency - i.e., by producing more food without increasing inputs through, for example, more efficient use of N, the Economic Breeding Index and future genetics. The main concern in this scenario is that – while there is real potential to 'pick the low hanging fruit' – efficiency cannot be increased indefinitely without introducing high costs. In other words, some gains in production can be achieved through efficiency alone, but there will be a point at which further increases in efficiency require methodologies or technologies that are cost-prohibitive.

Intensification - by increasing stocking rates (with associated higher inputs). The main concern under this scenario is the risk that the demand for denitrification rates (required to maintain groundwater nitrate level below 50 mg/L) may exceed maximum denitrification rates on drier, well-drained soils.

Expansion - by expanding the current area of intensive production into areas that are currently 'under-utilised' from an agricultural point of view. There are two concerns associated with this scenario: one is the potential impact of expansion on compaction risks on poorly-drained soils. Our research has shown that compaction not only increases the risk of environmental impacts, but can also significantly reduce the production potential of land. The second concern is the impact of expansion on biodiversity in semi-natural habitats, e.g., High Nature Value (HNV) farmland.

Summary

In principle, there is potential to meet both growth targets and environmental targets by 2020. However, this does require careful management – from the outset – of how growth can be achieved. Most likely, this will encompass a targeted mix of further gains in efficiency, intensification and expansion.

Teagasc's research programme is developing a mosaic of cost-effective mitigation strategies that will ensure that the green credentials of Ireland's agriculture will remain at the heart of its growth and competitiveness.

Table 1: Quantification of the 'supply' and 'demand' for five land use functions.

LAND USE FUNCTION	PROXY (IN THIS STUDY)	PROJECTED 'DEMAND' FOR SOIL FUNCTION	MAXIMUM 'SUPPLY' OF SOIL FUNCTION	CAVEATS/NOTES
Food, fibre and fuel production	Stocking rate	1.0 LSU[a] per hectare	1.5 – 1.8 LSU per hectare	Large differences in carrying capacity exist between contrasting soil types, from 0.5 – 3.0 LSU per hectare.
Water purification	Denitrification capacity	8 kg N per hectare per year	24 kg N per hectare per year	Large differences in denitrification capacity between soils and regions, from 5 – 63 kg per hectare per year.
	Phosphorus (P) sorption (Index 1 and 2 soils)	National P-"surplus": 2.2 kg per hectare per year	National soil P build-up capacity: 2-5 kg per hectare per year	The lack of P sorption capacity in soils with an organic matter content > 20% has been accounted for in these figures.
Carbon sequestration	Sequestration capacity by farm-afforestation	3.5 – 5.3 Mt CO_2e[b] per year	5.8 Mt CO_2e[b] per year	Requires significant acceleration in farm-afforestation rates to meet government targets. This Land Use Function should include carbon sequestration in grassland, but international scientific consensus on grassland sequestration rates has not yet reached conclusion.
Habitat for biodiversity	Above-ground biodiversity	1. Habitat Directive: SAC 2. Birds Directive: SPA designation 3. Strengthen conservation within designated habitats	- Natura 2000 sites - Non-designated peatland - Rare species - HNV farmland?	Obligations regarding Birds Directive and strengthening of conservation within designated habitats are currently not fully met.
Recycling of (external) nutrients	Recycling of P in pig manure	5,674 t P per year	Tillage + suitable grassland (Index 1 and 2): 29,509 t P per year	Large differences exist between regions in the availability of suitable tillage and grassland soils. Emerging demand for recycling of sewage sludge (EU Sewage Sludge Directive) may compete for recipient soils.

a: LSU = livestock unit. b: CO_2e = Carbon dioxide equivalent emissions.

Crop rotations for profit

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Dermot Forristal describes the impact of crop rotation on crop yield and profit using data from the Knockbeg Systems trial.

Rotations, where annual crops such as cereals are grown in sequence with break-crops of a different type, were an integral part of agricultural production until relatively recent times. The benefits of rotation include: maintenance of soil fertility; provision of breaks in disease and pest cycles; improved weed control opportunities, and reduction in peak labour demands. Increase in fertiliser use and the availability of chemical disease and weed control options reduced the need for rotation and allowed farmers to specialise in production systems and achieve cost savings. In Ireland, with the demise of sugar beet, break-crops now account for only 9.6% of the cropped area, indicating the common practice of continuous cereal production. The reliability of break-crop production has historically been questioned by growers with experience of variable yields and grain/produce price fluctuation. However, as much of our cropped land is now without rotation for a number of years, growers are questioning the profitability of continuous cereal production and re-evaluating break-crops and rotations.

Knockbeg systems trial

The Knockbeg systems trial was set up at a site adjacent to Teagasc, Crops, Environment and Land Use Research Centre, Oak Park, Carlow, in the late 1990s to determine the effects of rotation and input level on the performance of crops and on profitability. Two rotations and two monocultures were established on the moderately-heavy, free-draining loam soil as outlined in Table 1.

TABLE 1: ROTATION AND MONOCULTURE CROPPING DETAILS

Crop rotation	Break Crop Rotation (BC)	Cereal Rotation (CR)	Monoculture (C)	Monoculture (C)
1	W. Wheat	W. Wheat	W. Wheat	S. Barley
2	S. Barley	W. Barley		
3	S. Oilseed Rape	W. Oats		
4	W. Barley			
5	Beans			

Note: W= winter, S= spring,

The break-crop (BC) rotation has two non-cereal crops: oilseed rape acts as a disease break from cereals and also has a different rooting structure to cereals; beans also act as a disease break from cereals but, in addition, this leguminous crop can fix atmospheric nitrogen, thereby reducing the requirement for fertiliser nitrogen.

While the second rotation (CR) contains solely cereals, the winter oats crop provides a break from 'take-all' (*Gaumannomyces graminis*) fungal disease, which is a major threat in continuous wheat production. Winter wheat and spring barley were grown continuously as monocultures (C).

The level of inputs, such as fertilisers and fungicides/herbicides, were also evaluated in this trial. 'High' input levels were similar to those used by most intensive growers, whereas with 'low' inputs, approximately 80% of the applied nitrogen rates and 50% of the rates of herbicides and fungicides that were applied in the high input treatment were used.

Yield and profit – individual crops

An analysis of the rotation performance over the 2004 to 2010 period has recently been carried out (Forristal and Grant, 2011). The effect of break-crops on the yield and profit margin of the following cereal crop in the rotation was examined. The economic performance of the entire rotation was also determined. Appropriate statistical analysis for the complex replicated experimental design allowed all seven years to be examined. Winter wheat, spring barley and winter barley were each grown in more than one rotation and the yield and crop profit margin of these crops is given in Figures 1 and 2.

The effect of rotation on crop yield and margin in winter wheat depended on input level. Where input levels were low, rotation was much more beneficial for

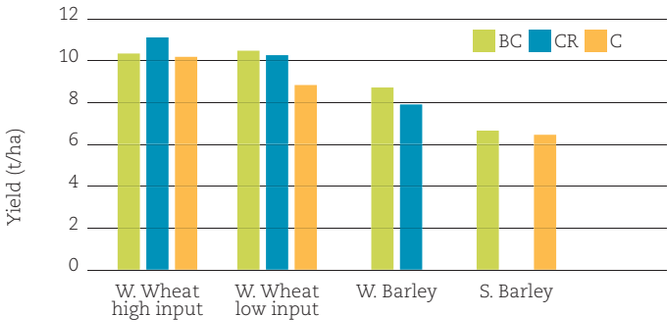

Figure 1: The impact of break–crop rotation (BC), cereal rotation (CR) or monoculture winter wheat and spring barley (C), on annual crop yield averaged over a seven year period. Winter wheat data is presented at two input levels.

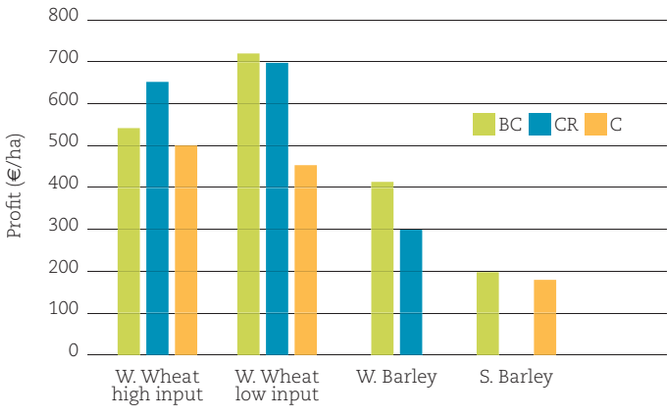

Figure 2: The impact of: break–crop rotation (BC), cereal rotation (CR) or monoculture winter wheat and spring barley (C), on annual crop profit margin averaged over a seven year period. Winter wheat data is presented at two input levels

yield than where input levels were high, with a difference of 1.6t/ha between continuous wheat and the average of the wheat yield in the two rotations. The rotation benefit was smaller where higher input levels were used. Interestingly, wheat grown following oats in the cereal rotation yielded at least as well as wheat grown after beans, which indicates that the main benefit of rotation for wheat was the effect on take-all. Where winter barley was grown after a break-crop it yielded significantly better and produced more profit than winter barley grown after wheat in the cereal rotation. There was no impact of rotation on spring barley production in this trial as the spring barley grown in rotation was planted following another cereal (wheat), and did not seem to benefit from the legume crop grown two seasons earlier.

Rotation profit

While cereals grown following a break-crop may have improved yield and profit, the overall profitability and viability of rotations depends on all the crops in the rotation. As the rotations had all crops grown in all years of the trial, an effective analysis of the two rotations compared with the spring barley and winter wheat grown in monoculture was possible with the Knockbeg data.

The net annual profit margin figures in Figure 3 show that the break-crop rotation was not as profitable as continuous winter wheat production at the Knockbeg site. The cereal rotation produced similar profit levels to continuous wheat while spring barley profit was poor particularly at low input levels. The profitability of the individual crops in the rotation and the combination of crops within the rotation contributed to this result.

Figure 3: The effect of break–crop rotation (BC), cereal rotation (CR) and monoculture winter wheat (CW) or spring barley (CB), on entire rotation profit margins, at two input levels averaged over a seven-year period.

Key points

- The modest yield performance, coupled with mediocre profit potential of the break-crops, resulted in the relatively poor performance of the break-crop rotation. The Knockbeg site is well-suited to wheat production.
- When considering rotations, the profitability of all of the component crops must be taken into account. It is likely that the relative performance of different crops will vary depending on site and soil type.
- Rotations are likely to be more beneficial where lower levels of inputs are used. Conversely, where rotations are employed, there may be scope to profitably adopt a low-cost production system.

The future

The challenges of cereal monoculture, which include yield limitations and the need for higher inputs, require us to re-evaluate the role of rotations. While rotations give us yield benefits by, for example, increasing the number of first wheats (i.e., wheat grown after a non-cereal or oats) grown, this research clearly shows that break-crops must also be profitable.

For rotations to succeed, profitable and reliable break-crops are essential. There is a need to actively identify and develop appropriate break-crops for our conditions and markets. Improving break-crop performance is not without challenge and will require a focused research programme. Plant breeding may improve break-crops in the longer term, however breeding capacity in this area is limited and it is essential to have focus on the traits that are important for our production conditions. In the short- to medium-term there is scope to improve yield and reduce the production risk with agronomy research. Progress will not be instantaneous, but a targeted research programme, coupled with a technology transfer campaign and industry support, should help deliver viable rotations and more sustainable production systems.

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Evaluation of soil quality for forestry

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Niall Farrelly, Forestry Researcher, Athenry, evaluates soil quality measures for use in forestry and concludes that the soil nutrient regime is the key variable influencing the height growth of Sitka spruce in Ireland.

How do soil taxonomy classes/soil classifications, used primarily to classify soils based on their soil forming and developmental processes, reflect the levels of nutrient availability for plant growth? How do other measures of soil quality - which include various quantitative physical and chemical measures - reflect the available nutrients in forest soils? Soil quality classifications in use in forestry in British Columbia, Canada, have shown strong relations to tree growth. These classifications work effectively by classifying soils into homogenous groups of soil moisture (based on the average amount of water annually available for growth by vascular plants) and soil nutrient regime (the level of nutrients available for plant growth). The presence or absence of certain indicator plants on a forest site is used to classify the soil quality based on a soil quality grid, a two-dimensional matrix of available nutrients and moisture (Green and Klinka, 1994) (see Table 1).

Methods for the assessment of soil quality

This study therefore set out to explore what measures of soil quality gave the best indication of soil quality in forest soils and how these measures related to the productivity of Sitka spruce in Ireland. The aim was that results would be used to assess the likely potential productivity of the species. To compare and contrast different measures of soil quality, soil classification data (great soil group, soil subgroups) and various physical and chemical quantitative variables were analysed to determine their effect on the growth of Sitka spruce. Quantitative variables included: organic matter; soil water content; total rooting depth; soil pH; available phosphate (P), potassium (K) and magnesium (Mg); available nitrate-N (NO_3-N) and ammonium-N (NH_4-N). The soil chemical analysis was performed by the soil laboratory at Teagasc Johnstown Castle Environment Research Centre. To supplement these soil quality measures, the soil moisture regime of soils was determined using the ratio between actual and potential evapotranspiration, the occurrence and depth of watertable and depth of prominent mottling (Farrelly, 2011). Soil nutrient regimes (SNR) were identified using a combination of soil morphological properties and the weighted average indicator species scores for available nutrients provided by Ellenberg (1988). The crop response variable at each site was assessed using an index of height growth (site index; height growth of dominant trees at 30 years).

Site with very poor soil nutrient regime indicated by the presence of heather *(Calluna vulgaris)*.

Table 1: The soil quality grid used for forestry in British Columbia, Canada with characteristic indicator plants and their related moisture and nutrient regimes.

SOIL MOISTURE REGIME	SOIL NUTRIENT REGIME					
	VERY POOR	POOR	MEDIUM	RICH	VERY RICH	CARBONATE
Very Dry						
Moderately Dry						
Slightly Dry			Wood sage			
Fresh	Cowberry	Bracken		Bluebell	Elder	
Moist	Heather	Wood sorrel			Stinging nettle	
Very Moist			Lady fern			
Wet				Meadow-sweet		
Very Wet	Bog myrtle					

Site with rich soil moisture regime indicated by the presence of bramble (*Rubus fructicosa*) and ivy (*Hedra helix*)

Analysis and results

Multiple regression analysis was used to assess which measures of soil quality showed the strongest relationship with height growth of Sitka spruce. In terms of soil classification, results of the analysis indicated that great soil group (nine classes) was only moderately successful in explaining the difference in height growth among sites - accounting for 28% of the explained variation. Further differentiation down to subgroup (with 20 soil classes) explaining more of the variability in height growth (45%). The quantitative soil quality variables were only moderately successful (with rooting depth and organic carbon accounting for 33% of variation) and soil chemical measures (soil pH, log K, Mg and NO_3-N - explaining 32% of the variation) in the height growth of Sitka spruce.

This study found that among the soil quality measures examined, soil nutrient regime (five classes) was the best measure of site quality - explaining 51% of the variation in height growth. Height growth increases significantly with increasing soil nutrient regime, reaching a maximum on very rich sites (Figure 1). The best growth of the species occurs on fresh to very moist sites with rich to very rich soil nutrient regimes (Figure 2).

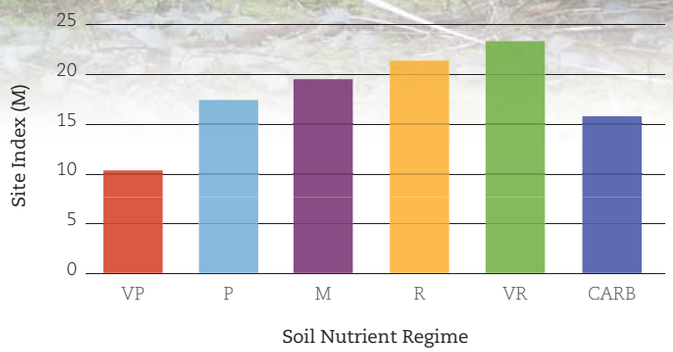

Figure 1. Height growth of Sitka spruce in relation to increasing soil nutrient regime (VP, very poor; P, poor; M, medium; R, rich; VR, very rich; CARB, carbonate).

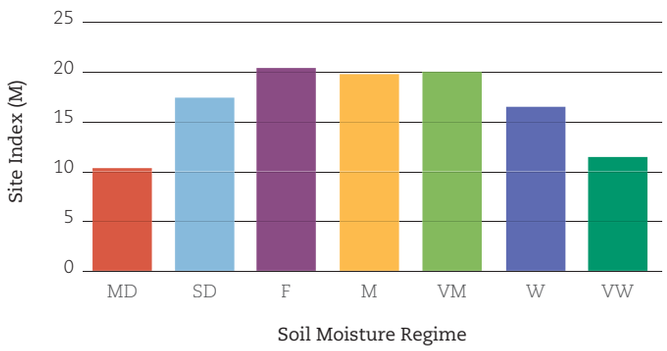

Figure 2. Height growth of Sitka spruce (30 years) in relation to increasing soil moisture regime (MD, moderately dry; SD, slightly dry; F, fresh; M, moist; VM, very moist; W, wet, VW, very wet).

Benefit to industry

All the soil quality variables examined show significant relationships with the growth of Sitka spruce. The best measure of soil quality was soil nutrient regime, which explained over half the variation in growth of the species. Other soil physical and chemical properties were less strongly related to the growth of the species and are less well defined in terms of soil quality.

The classification of soil quality based on soil taxonomy offers some potential - provided it is at soil subgroup or soil series level. However, it should be borne in mind that classification of soils based on developmental processes rather than soil quality criteria may classify soils with similar nutrient availabilities into separate classes.

The reason for the success of soil nutrient regime in determining site suitability is that it works by grouping soils into relatively few classes with similar nutrient availability where their effect on the growth of tree species or plants can be effectively evaluated. Thus, soil nutrient regime is a good measure of soil quality for use in forestry in Ireland. Importantly, the study established where forest production can be maximised, i.e., on fresh to very moist sites with rich to very rich nutrient regimes. Thus, significant potential exists to increase yields in our planting programme through adequate site selection.

Acknowledgements

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Milk quality maintaining standards

A cross-disciplinary team of Teagasc researchers are tackling the industry challenge of producing premium quality milk while continuing to meet increasing specifications.

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Ireland is currently well recognised internationally for the production of very good quality milk and this premium quality status will need to be maintained, and improved upon, for the long-term future of the export market and the interests of the consumer. The proposed removal of quotas in 2015 will likely lead to an increase in milk production, as forecasted by the Department of Agriculture, Food and the Marine's *Food Harvest 2020* report. This will necessitate a focus on milk quality research to ensure the production of premium quality milk for an extended manufacturing season. *Food Harvest 2020* predicts a 50% increase in milk production by 2020 (above the average 2007 to 2009 baseline). This equates to a 2.75 billion litre increase in milk production that would add value to primary output by about €700 million/year, with further benefits from increased dairy product values, export earnings and employment.

In parallel, milk processors are setting higher specifications for milk quality including improved bacterial quality, decreased somatic cell counts (SCC) and residue concentrations, required by export markets. The EU has set a legislative SCC limit of $\leq 400 \times 10^3$ cells/ml (which is generally met), but some markets are now requiring milks to meet a specification of $\leq 200 \times 10^3$ cells/ml, and it is generally accepted that a lower specification will be required in future. Also, in order to accommodate the increased milk processing volume, an extension of the duration of the product manufacturing season is required. So, a significant challenge exists to continue producing premium quality milk in light of tighter standards, expanding herd size on farms, reduced labour availability and recent changes in animal treatments and legislation.

How are these issues being addressed?

The issues mentioned require a multi-disciplinary approach. Teagasc is ideally placed to deal with such issues as it is one of the few Agricultural Research and Development Agencies globally that has the capacity to deal with the complete 'milk pipeline' from 'farm to fork'.

Teagasc has established:

- an internally co-ordinated approach to milk quality that involves researchers at the Animal and Grassland Research & Innovation Centre, Moorepark, the Food Research Centres (Moorepark and Ashtown) and the Farm Advisory Group.
- interaction with industry mainly through the establishment of the Milk and Product Quality Forum in 2009. This group represents key dairy industry stakeholders including quality managers and/or quality advisors from the dairy companies and members of other organisations (e.g., Irish Dairy Board) associated with the promotion of the Irish dairy industry. It provides a forum where new milk and product quality issues may be identified and existing issues addressed. It also assists in the dissemination of key research findings to the industry.
- international collaboration with, for example, (i) Professor Ruegg, University of Wisconsin-Madison, USA, who is recognised as a world leader in the field of food microbiology and milk quality; and (ii) a joint study with DairyNZ (Dr Jenny Jago) and Massey University, New Zealand, is evaluating labour efficiency in milking parlours with particular reference to influences on milk quality.

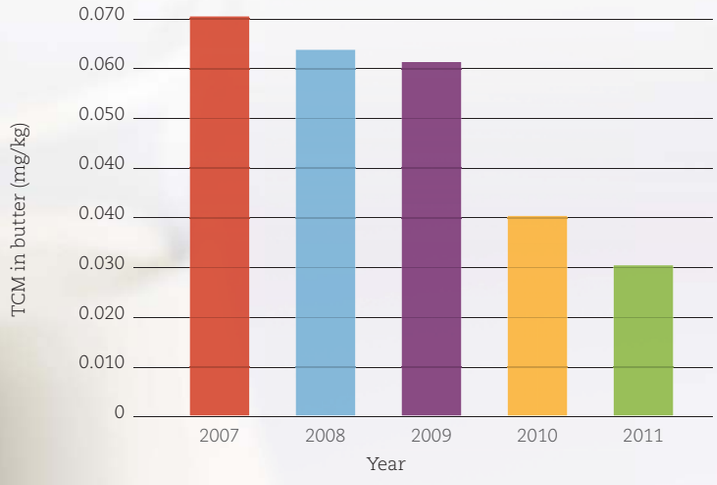

Figure 1. Profile of TCM reduction in Irish butter from an initial high of 0.07 mg/kg to the target level of 0.03 mg/kg.

As the dairy industry develops and expands over the coming decade it will be vital that the clean, green image of the Irish dairy industry is maintained. Image courtesy Bord Bia.

Current milk quality research highlights

Food Institutional Research Measure: a project has been funded and recently commenced under the Department of Agriculture, Food and the Marine's FIRM programme. Its aim is to collate all recent Irish and international research on a number of aspects of milk quality in order to identify the gaps in knowledge and those aspects requiring specific attention.

Bacterial transfer to milk: The effectiveness of a range of milking equipment cleaning products and procedures are currently being evaluated. A key output of this research is a detergent efficacy list which is available on the Teagasc website (http://www.agresearch.teagasc.ie/moorepark/Articles/Chemicalanalysisofdetergentsterilizerproducts.pdf). The increasing importance of infant formula manufacture has lead to a new focus within the programme, i.e., the occurrence and control of *Bacillus cereus* and sulphate-reducing clostridia (SRC) in farm bulk milk.

SCC Reduction: The impact of milk SCC on milk chemistry and cheese manufacture is currently being addressed. The reduction of milk SCC on-farm is the focus of CellCheck, a joint programme being run by Animal Health Ireland and Teagasc. SCC and its impact on farm profitability has been the subject of a recent article in *TResearch* (Winter 2011, p22-23).

Chemical residues: Trichloromethane (TCM) levels in butter are an important market-driven concern for the dairy industry at present. An industry-funded project at Teagasc has addressed this issue for the last four years and significant progress has been achieved. Figure 1 shows the gradual reduction of TCM in butter from 0.07 mg/kg in 2007 to 0.03 mg/kg in 2011. This was achieved through farm visits to identify incorrect practices, advice on the correct practices allied with a vigorous advisory campaign through Teagasc and the dairy companies and, most importantly, an intensive analysis programme. Routine screening for TCM in both tanker milks and individual suppliers' milk resulted in analysis of approximately 25,000 milk samples during 2011.

Liver fluke: Liver fluke continues to be an issue on many Irish farms; however, there are few flukicides available to assist farmers to control this problem in dairy cows. Research at Teagasc has followed the persistence and stability of various flukicide residues during pasteurisation, separation and manufacture of dairy products, including cheese and milk powder. Results show that residues are carried over into the dairy products and are stable therein. This poses a serious challenge for industry and further research is required.

Future

As the industry develops and expands over the coming decade it will be vital that the clean, green image of the Irish dairy industry is maintained. New markets and new products, along with the need to link quality milk production to our seasonal supply will continue to impose new challenges to the industry. A strong research base in quality milk production and processing with solid links to the dissemination capacity of the Teagasc Dairy Advisory group and the key industry stakeholders will be vital if these challenges are to be addressed in a positive and adequate manner.

CheeseBoard 2015

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A new national cheese research programme featuring all the major cheese research institutions recently got underway.

Teagasc was announced as coordinator of a major new €1.3m national research project entitled 'National Cheese Research Programme 2015'.

Five participating academic and research institutions on the island of Ireland are combining their respective competencies to provide an integrated approach to challenges in cheese research that are deemed critical for the future development of this food industry sector. The participating research teams that constitute the 'Irish Cheese Research Consortium' (ICRC) include: Teagasc Food Research Programme Moorepark and Ashtown, University College Cork, University of Limerick, University College Dublin and Agri-Food BioSciences Institute (AFBI, Northern Ireland). With the acronym 'CheeseBoard 2015', reflecting the imminent opportunity and challenges that the Irish dairy industry faces with the ending of EU milk quotas in 2015, the project will be co-ordinated by Dr Phil Kelly and guided throughout its four-year duration by means of market intelligence and consumer interaction. Stakeholder representation includes cheese manufacturers, participating research institutions, Bord Bia, Enterprise Ireland and a Food Institution Research Measure/Department of Agriculture, Food & the Marine representative.

Significant expansion in cheese production

The ICRC embraces the Irish dairy industry's forecast (reflected in *Food Harvest 2020*) for significant expansion in cheese production, both in overall volume and in specific varieties, over the next 10 years. Drawing on substantial experience of supporting the cheese industry over the past 30 years, with the development of robust cheese starter cultures, technological underpinning of Irish Cheddar production and development of novel hybrid cheeses, the consortium is well positioned to support immediate work on the production of reduced-fat, low-salt cheese variants to address growing health concerns, as well as addressing longer term cheese diversification opportunities.

Cheese diversification: improved nutrient profiling and flavour innovation

The research programme will be accomplished by means of six tasks – three of which deal with the scientific and health aspects of natural cheeses which, along with a further task on processed cheese (Task 2), will be informed by the outcomes of consumer studies (Task 6). A separate task, involving Teagasc (Drs Catherine Stanton and Andre Brodkorb and Professor Gerard Downey) and AFBI (Dr Ann Fearon), sets out to develop a rapid assay for trans fatty acids (TFA), which should also be capable of differentiating between naturally-occurring TFA in milk fat (healthy form) and those originating from the hydrogenation of vegetable oils.

New scientific thinking is being brought to bear by Professor Tim Guinee (Teagasc) in order to improve the texture of reduced fat cheese, e.g., use of soft matter concepts such as 'jammed polymer networks' to open up cheese matrices in the first instance before exploring the interaction with new flavour compensating culture techniques.

Advanced techniques in cellular metabolism (e.g., flow cytometry) and molecular biology (e.g., pyrosequencing) will be respectively employed by Dr Martin Wilkinson (University of Limerick) and Dr Paul Cotter (Teagasc) to optimise the starter culture characteristics (Dr Kieran Kilcawley, Teagasc; Professor Douwe van Sinderen, UCC) in improved reduced-salt/reduced-fat cheese matrices, and establish the extent to which variation in indigenous microflora affects cheese quality, particularly among non-Cheddar varieties.

This is expected to not only guide the implementation of better microbiological control, but also to be the basis for the harvesting of new adjunct cultures for exploitation in cheese diversification led by Dr Diarmuid Sheehan (Teagasc). Recent developments that highlight the positive role of dietary milk calcium in weight management will be investigated by Dr Tom Beresford and Dr Linda Giblin (Teagasc) using reduced-fat, and calcium-fortified cheese products to establish if increased concentrations of calcium and vitamin D can reduce adiposity in animal models (Dr Kanishka Nilaweera, Teagasc) by influencing lipogenesis and lipolysis in the adipose tissue through a reduction in plasma levels of parathyroid and calcitrol hormones. Increased fat excretion would reduce the amount of dietary fat available for absorption through the intestine.

Reduction in sodium content of foods is currently a major focus of the Irish food industry, owing to the association of excessive dietary intake with hypertension and related illness. Fundamental studies on the mechanistic role of emulsifying salts on protein hydration by Professor Dolores O'Riordan and her team at UCD will seek to reduce the sodium content in reduced-fat processed cheese matrices.

Expected impact of research outputs to end user

TASK 1: Reduced fat/salt cheeses with improved texture and flavour

It is urgent that significant strides are made in reducing the levels of salt (sodium) in cheese, as some jurisdictions are pushing industry for voluntary lowering of such levels in order to avoid punitive nutrition messages being labelled on such dairy products. If this can be achieved at the same time as reducing the hardness of low fat cheese, then consumers will be given more satisfactory cheese purchasing options. The CheeseBoard 2015 research team face considerable technical challenges when attempting to optimise the quality of half-fat, reduced-salt Cheddar cheese-type products, through improvements in cheese matrix properties, advancing/optimising starter culture selection and technology, and their interaction with the matrix.

TASK 2: Application of cheese curd in processed/other applications for cheese

A deeper understanding of structure development in processed cheese that occurs during manufacture is aimed for. This advancement in knowledge will lead to product reformulation which will enhance processed cheese:

- Dairy companies will be able to adopt innovative ingredient technology to formulate processed cheese products with enhanced nutritional profiles, functionality, sensory attributes and potential health benefits.
- End product concepts will have potential for retail market exploitation and for the manufacture of customised products for industrial use or for the fast food sector.

TASK 3: Cheese as a vector for bioactives/probiotics/vitamins/minerals

If it is successfully demonstrated that a low-fat cheese (ideally sourced as an outcome/deliverable from Task 1) enriched in calcium and vitamin D lowers weight in animal studies, then there will be an urgency to undertake follow-up clinical trials to validate this finding *in vivo* and establish a case for a clear health benefit.

TASK 4: Combination of advanced molecular biology analytical techniques with technological innovation to support development of new cheese varieties and diversification of the existing product portfolio

Greater cheese diversification opportunities are anticipated when it can be successfully demonstrated that leading edge molecular biological assays may be used to characterise adventitious microflora during cheesemaking. This should lead to enhanced quality and innovations in the manipulation of physicochemical, technological and microbial parameters for the benefit of existing varieties and new cheese types, e.g., (i) modify texture in dry salted Cheddar-variants and brine-salted continental cheese-types, and, (ii) modulate and intensify the flavour profile of novel dry-salted Cheddar variant cheeses.

TASK 5: Analytical techniques capable of differentiating between natural and industrial trans fats

It is anticipated that research focused on the use of rapid analytical spectroscopic techniques offers the best opportunity for more dairy and food companies to have immediate profiles of their TFA levels. Thus, the study will subject a large set of food samples including margarines, edible oils and dairy products to regular chemical analysis for trans fats as well as non-destructive analysis using techniques such as Fourier Transform Infrared spectroscopy, Near-infrared spectroscopy and Raman spectral regions in order to ascertain the potential to develop reliable rapid test(s) for this purpose.

TASK 6: Knowledge of the drivers of consumer choice/perception/acceptance with respect to cheese

Feedback from market and consumer studies (Dr Sinead McCarthy, Teagasc) will inform the project with up-to-date views on consumer concerns regarding their purchasing and dietary behaviour.

This research is funded by the Food Institution Research Measure (FIRM) administered by the Department of Agriculture, Food & the Marine.

Irish research institutions are combining their respective competencies to provide an integrated approach to challenges in cheese research that are deemed critical for the future development of this food industry sector. Image courtesy Bord Bia.

Shelf-life of food

Dr Gerard Barry explains what food manufacturers need to know about the shelf-life of ready to eat foods under EU Regulation 2073/2005.

Food product shelf-life is often taken for granted, and initially appears to be a relatively simple issue. However, when scrutinised in detail it readily becomes apparent that there is significant complexity in deriving and achieving food product shelf-life. In this regard, ready to eat (RTE) foods, i.e., foods that will not be cooked or reheated before serving, pose the biggest challenge.

Where a food safety risk arises due to potential presence of pathogens (high risk foods) the shelf-life is indicated by a "use by" date. In comparison the "best before date" is reserved for foods whose spoilage relates to quality issues.

Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs has highlighted a number of new issues that require consideration when establishing shelf-life for RTE foods.

Key issues raised in current legislation

It is clearly established in the legislation that the food business operator (FBO) is responsible for ensuring that food placed on the market is safe, and imposes the requirement to test product for mandated requirements and assigning a valid shelf-life. This validation must be based on objective data and, for products with a use-by date, derived by a competent and, ideally, accredited laboratory.

In assigning a shelf-life, consideration must be given to "reasonably foreseeable conditions of distribution, storage and use"; handling and storage conditions in the food chain up to the point of consumption must be considered. The food safety criteria stated in Regulation 2073 are applicable throughout shelf-life and, for stated categories of product-specific criteria, are documented for designated microorganisms of concern. These criteria are set out stating: M, the maximum permitted limit, m, the desired limit, n, the number of units comprising a sample, and c, the number of sample units giving results between m and M.

Contravening the stated limits in the legislation requires product to be withdrawn or recalled.

Limits for *Listeria monocytogenes*

The regulation has set two limits for *Listeria monocytogenes* in RTE foods. The FBO must decide which limit to adopt. It is important to make a distinction between foods that are able/unable to support the growth of *L. monocytogenes*. The legislation gives the following guideline and defines appropriate limits:

Food Category 1.2	Ready-to-eat foods able to support the growth of *L. monocytogenes*, other than those intended for infants and for special medical purposes
Sampling Plan	n=5, c=0
Limits	**Limit 1:** 100 cfu/g. Note 5: This criterion shall apply if the manufacturer is able to demonstrate, to the satisfaction of the competent authority, that the product will not exceed the limit of 100 cfu/g throughout the shelf-life. The operator may fix intermediate limits during the process that must be low enough to guarantee the limit of 100 cfu/g is not exceeded at the end of shelf-life **Limit 2:** Absence in 25g. Note 7: This criterion shall apply to products before they have left the immediate control of the producing food business operator, when they are not able to demonstrate to the satisfaction of the competent authority that the product will not exceed the limit of 100 cfu/g throughout shelf-life
Sampling Plan	n=5, c=0 (Limit 1 and Limit 2)
Stage where criterion applies	**Limit 1:** Products placed on the market during their shelf-life **Limit 2:** Before the food has left the immediate control of the food business operator, who has produced it
Food Category 1.3	Ready-to-eat foods unable to support the growth of *L. monocytogenes*, other than those intended for infants and for special medical purposes (note 4 & 8 apply)
Sampling Plan	n=5, c=0
Limit	100 cfu/g
Stage where criterion applies	Products placed on the market during their shelf-life
Note (4)	Regular testing against this criterion is not required in normal circumstances for the following ready-to-eat foods: those that have received heat treatment or other processing effective to eliminate *L. monocytogenes*, when recontamination is not possible after this treatment (for example, products heat treated in their final package): • fresh, uncut and unprocessed vegetables and fruits, excluding sprouted seeds • bread, biscuits and similar products • bottled or packed waters, soft drinks, cider, wine, spirits and similar products • sugar, honey and confectionery, including cocoa and chocolate products • live bivalve molluscs • food grade salt
Note (8)	Products with pH < 4.4 or Aw < 0.92 Products with pH < 5.0 and Aw < 0.94 Products with a shelf-life of less than five days shall be automatically considered to belong to this category. Other categories of products can also belong to this category, subject to scientific justification

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There is, however, an anomaly for products with less than five days shelf-life, e.g., ready made sandwiches which may have *L. monocytogenes* present, and potentially at unacceptable levels, a concern as *L. monocytogenes* grows at chill temperatures.

An important consideration is which limit should an FBO adopt? Absence is the desired status. If absence is chosen and *L. monocytogenes* is found present in the product at any stage in shelf-life, in the absence of proof available from the FBO that the limit of 100cfu/g will not be breached throughout the product shelf-life, the product must be withdrawn/recalled.

Where a product has a potential for presence of *L. monocytogenes*, adopting absence of the organism incurs the risk of product withdrawal/recall, and all the attendant costs and reputational damage. The alternative is to establish whether the organism will grow or not in the product in the first instance. If growth potential exists, a challenge test with *L. monocytogenes* is required to establish compliant limits, which can be applied to any stage in shelf-life. This will prevent an unnecessary withdrawal/recall. If no growth potential exists, but presence is possible, monitoring is required is to establish that the limit is not breached.

Determining shelf-life

Planning of shelf-life is shown in Figure 1. A risk assessment based on a combination of historical bacteriological data, performance of product and epidemiological data, is required to ascertain what types of bacteria are of concern (if any) that will cause spoilage and or food poisoning. Information on intrinsic factors such as pH, water activity (Aw), preservative and salt level, etc., together with extrinsic factors such as processing steps, atmosphere, storage temperature, etc., is also considered.

Where a shelf-life requires microbiological testing, it is necessary that all potential microorganisms of concern are evaluated in the agreed protocol. Product must be produced and packaged under "standard production conditions" for the shelf-life test to be valid.

An indicative guideline is as follows:

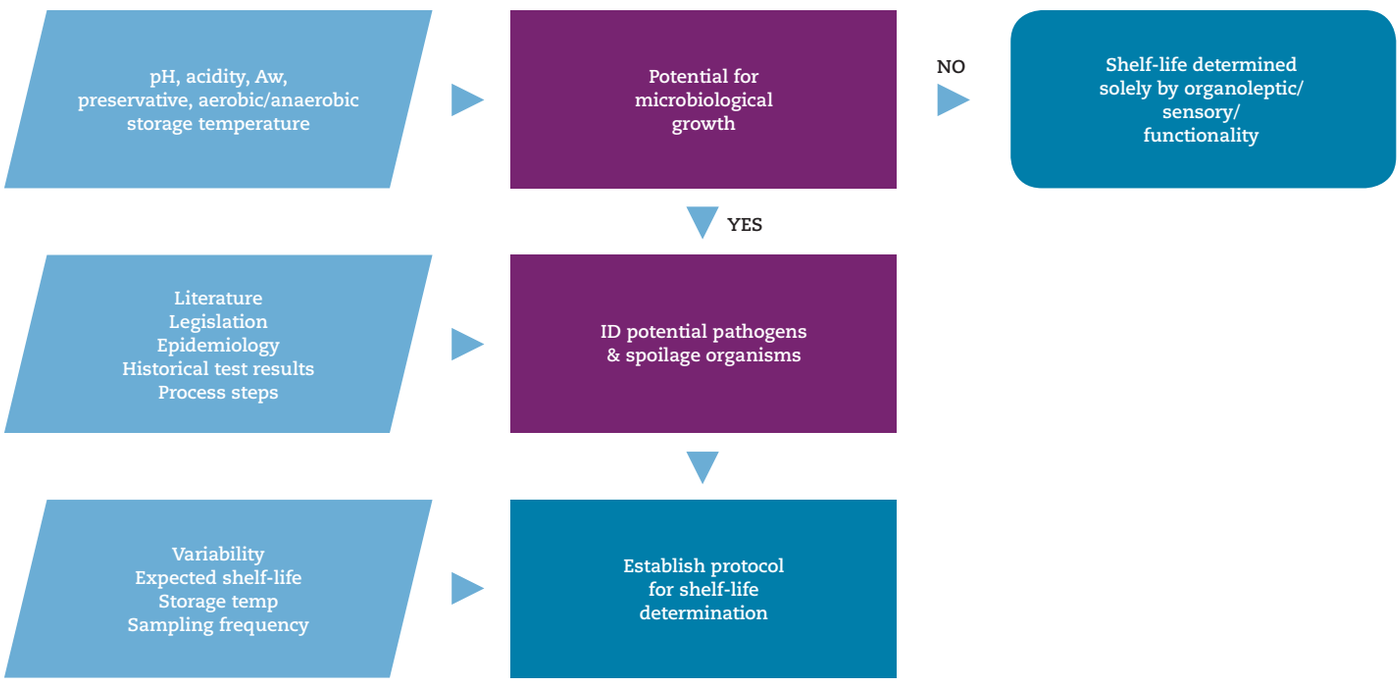
Stage of shelf-life	Spoilage organisms/ bacteriological load	Potential pathogens
Day 0	Yes	Yes
Intermediary days, e.g., 85% & 95% shelf-life	Yes	Yes, do if present
Day end shelf-life	Yes	Yes
Day end shelf-life + x days	Yes	Yes

The storage temperature adopted should take into account likely temperature abuse present in the food chain, ideally based on objective data generated in house and in the literature. The shelf-life test should be designed to produce the required information. The samples chosen for test should be from a batch representative of production. If batch variation is an issue more than one batch should be tested. It is also useful to verify shelf-life by storing product under "foreseeable conditions" and test at day end. This gives additional data over time and minimises cost.

Importance to industry

It is clear that the current legislation is more demanding than heretofore in terms of what is required for RTE food shelf-life. It also promotes a scientific approach. Teagasc's Food industry Department will be monitoring the legislation and advising producers as issues arise.

Figure 1: Planning shelf-life protocol.



Dublin City of Science

Dublin has been designated as European City of Science for 2012. During the year, a large number of scientific events will be organised in Dublin and nationally in order to showcase Ireland's growing capacity in science.

The highlight of the year will be the Euroscience Open Forum (ESOF 2012), which will be held in the new Conference Centre in Dublin on July 11-15, 2012. This event will bring together 6,000 scientists, business leaders, government officials and international media to discuss the best of European science and to address all of the major global challenges, including energy, climate change, food and health.
The City of Science year will also see a programme of other science-related events all round the country. This programme will embrace a wide range of events designed to encourage the public to engage with science. Teagasc is contributing to this programme by way of a series of conferences, workshops, exhibitions, schools visits, etc. These events will be branded with the City of Science logo and will be promoted through the City of Science website.

www.teagasc.ie/research/cityofscience

MARCH

Teagasc College open days

Career guidance teachers and students will have a unique opportunity to get fully updated on all new courses at these special careers events, organised by Teagasc. As well as hearing the full story on all new courses in agriculture, horticulture, horses and forestry, they will also receive information on the diverse range of career opportunities available to graduates.
For further information: www.teagasc.ie

APRIL

11 – 12 April *Rochestown Park Hotel, Cork and Teagasc, Moorepark, Fermoy, Co Cork*

Moorepark Dairy Fertility Conference

To address the needs of the dairy industry with the pending removal of quotas, Teagasc is organising a fertility conference and workshop. The first day (April 11th) will take place at Rochestown Park Hotel. The second day (April 12th) will take place at Moorepark. Day 1 is open to anyone who wishes to attend (advisors, feed industry, AI industry, farmers etc.). Day 2 is confined to vets. For further details, contact Dr Stephen Butler: stephen.butler@teagasc.ie

25 April *Hodson Bay Hotel, Athlone, Co. Roscommon*

National Bioenergy Conference 2012

The Teagasc National Bioenergy Conference 2012 in association with Department of Agriculture Food & Marine will take place in the Hodson Bay Hotel, Athlone, Co. Roscommon on Wednesday April 25th.
For more information visit www.teagasc.ie

25 – 26 April *Castleknock Hotel & Country Club, Dublin*

NutraMara Conference

This event will play host to a number of internationally recognised speakers in marine research and includes participants from Canada, Australia, Norway, Spain, France, the UK, Iceland and the Netherlands as well as Irish researchers and industry representatives. For further details see: www.nutramara.ie/news-events/nutramara-conference-2012/conference-details/ or contact Dr Maria Hayes: maria.hayes@teagasc.ie

MAY

10 May *Aviva Stadium, Dublin*

Teagasc Food Technology Expo and Launch of Compendium of Technologies

Exhibition and demonstration of key Teagasc technologies available for uptake by the food industry. Further details at: www.teagasc.ie or contact : Dr Declan Bolton: declan.bolton@teagasc.ie

17 – 19 May *Teagasc Food Research Centre, Ashtown, Dublin*

Policy Farm Level Modelling Workshop

The workshop is being run in association with the European Meeting of the International Microsimulation Association. It is open to all areas of Farm Level Modelling including systems modelling and farm level policy modelling. Contact Dr Cathal O'Donoghue: cathal.odonoghue@teagasc.ie

28 May – 1 June *Rochestown Park Hotel, Cork*

ICAR (International Committee for Animal Recording) 2012 Conference

International conference organised by ICAR and sponsored by Teagasc, ICBF, Department of Agriculture, Food and the Marine, Irish Farmers' Journal, FBD Trust and Sheep Ireland. Further details at: www.icar2012.ie/index.php

JUNE

26 – 29 June *Wexford Opera House, Wexford*

New Horizon: 17th International Nitrogen Workshop-Innovations for Sustainable Use of Nitrogen Resources

An international workshop focusing on the sustainable use of nitrogen in ensuring food security. Jointly organised by Teagasc and AFBI (Northern Ireland). For further details: www.nitrogenworkshop.com Contact Dr Karl Richards: karl.richards@teagasc.ie

30 June *Teagasc Centre, Athenry, Co Galway*

Sheep 2012. The Way Forward

Seminars, workshops and exhibitions aimed at all involved in the Irish sheep industry. Contact Prof. Michael Diskin: michael.diskin@teagasc.ie or visit www.teagasc.ie

JULY

10 July *Dublin*

A Harvest of Irish Food

A public event jointly organised by Teagasc, UCD, DIT, TCD, Bord Bia, Enterprise Ireland and the Irish food industry to promote Irish food and its underlying science.
Further details at: www.teagasc.ie or contact Mr Declan Troy: declan.troy@teagasc.ie

12 July *Convention Centre, Dublin*

Milk: Nature's Perfect Food

Scientific session organised by Teagasc as part of the ESOF 2012 Scientific Programme, aimed at scientists, policy makers , media, industry students and general public. Contact Professor Paul Ross: paul.ross@teagasc.ie

13 July *Convention Centre, Dublin*

The Great Debate on the Battle to Feed a Changing Planet

Scientific session organised by Teagasc and the EU Joint Programme Initiative on Agriculture, Food Security and Climate Change (FACCEJPI) as part of the ESOF 2012 Scientific Programme. Aimed at scientists, policy makers, media, industry students and general public. Contact Dr Rogier Schulte: rogier.schulte@teagasc.ie