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T Research

Research and innovation news at Teagasc

Growing grass for a green biorefinery – an option for Ireland?

- Mind the gap: deciphering the gap between good intentions and healthy eating behaviour
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- A milk processing sector model for Ireland

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T Editorial

Food Harvest 2020 – the next step

There has been a broad national welcome for the Department of Agriculture, Fisheries and Food's (DAFF) *Food Harvest 2020* report. It outlines the key actions required to ensure that this indigenous sector of the Irish economy will play a pivotal role in an export-led economic recovery. Ambitious targets for the sector are set: achieving an export target of €12 billion by 2020.

The report sets out a conceptual framework for achieving these targets in terms of 'Acting Smart, Thinking Green and Achieving Growth'. The report makes a series of sectoral recommendations that must be actioned to deliver the growth targets. The DAFF has established an implementation group to ensure that the report's recommendations are effectively executed.

Of the three concepts, 'Growth' is best defined and targeted. It requires farmers to increase the outputs of goods and services required by consumers from farmers and processors to increase the market value of these outputs through processing.

The concept of 'Smart' is broadly defined as the investment in the agri-food knowledge management and innovation systems – research, knowledge transfer and education – that will provide producers and processors with the knowledge and skills to recognise and respond to the emerging opportunities/challenges. The delivery challenges include reduced investment capacity in the current economic climate and the requirement to measure the economic and social return. This is amplified by the fact that there is no 'one size fits all' option (e.g., dairy expansion).

The concept of 'Green' covers the production and processing practices that are synonymous with sustainable and welfare-friendly products. Similar to the recent Bord Bia *Pathways for Growth* report, the concept is that Ireland's competitive advantage in the very competitive international food marketplace will be improved by proven branding based on environmental enhancement of production and processing systems. The establishment of these environmental standards, or targets, and the provision of the evidence that they are being achieved, represent a significant challenge.

Teagasc is represented on the implementation group and will be collaborating and co-operating with stakeholders in realising the *Food Harvest 2020* vision.

Professor Gerry Boyle
Director of Teagasc

Food Harvest 2020 – an chéad chéim eile

Cuireadh fáilte náisiúnta leathan roimh thuarascáil *Food Harvest 2020* de chuid na Roinne Talmhaíochta, Iascaigh agus Bia (DAFF). Leagann sí amach na príomhghníomhuithe atá riachtanach le cinntiú go mbeidh ról maighdeogach ag an earnáil dhúchasach seo sa gheilleagar Éireannach i dtéarnamh geilleagrach bunaithe ar onnmhairiú. Leagtar amach spriocanna uaillmhianacha don earnáil: sprioc onnmhaire €12 bhilliún a bhaint amach faoi 2020.

Leagann an tuarascáil creat coincheaptúil amach chun na spriocanna seo a bhaint amach i dtaca le 'Ag gníomhú go Cliste, Ag Smaoineadh ar Ghlas agus Ag Baint Fás Amach'. Sa tuarascáil tugtar sraith de mholtaí earnála is gá a chur i gcrích le spriocanna fáis a bhaint amach. Tá Grúpa Forfheidhmithe bunaithe ag DAFF le féachaint chuige go gcuirtear moltaí na tuarascála i bhfeidhm go héifeachtach.

I measc na dtrí choincheap, is é 'Fás' atá sainmhínithe agus sprioctha ar an dóigh is fearr. Éilíonn sé ar fheirmeoirí aschur d'earraí agus de sheirbhísí atá de dhíth ar thomhaltóirí ó fheirmeoirí agus ó phróiseálaithe chun luach mhargaidh na n-aschur seo a mhéadú trí phróiseáil.

Sainmhínítear an coincheap de 'Cliste' go leathan mar infheistíocht sna córais bainistíochta faisnéise agus nuálaíochta agraibhia – taighde, aistriú faisnéise agus oideachas – a sholáthróidh faisnéis agus scileanna do tháirgeoirí agus do phróiseálaithe chun na deiseanna/na dúshláin atá ag teacht chun cinn a aithint, agus chun freagairt dóibh. Áirítear leis na dúshláin seachadta ná toilleadh infheistíochta laghdaithe sa timpeallacht reatha eacnamaíoch, agus an riachtanas chun an toradh eacnamaíoch agus sóisialta a thomhas. Ós rud é nach bhfuil aon rogha 'méid amháin do chách' ann (m.sh., leathnú déirithe), méadaítear é seo.

Clúdaíonn an coincheap 'Glas' na cleachtais tháirgthe agus phróiseála atá comhchiallach le táirgí inbhuanaithe agus leas-chairdiúla. Cosúil le tuarascáil Bhord Bia le déanaí *Pathways for Growth*, is é an coincheap atá ann ná go mbeidh buntáiste iomaíoch na hÉireann san áit mhargaidh bhia idirnáisiúnta atá an-iomaíoch feabhsaithe ag brandáil chruthaithe bunaithe ar fheabhsú timpeallachta de chórais tháirgthe agus phróiseála. Is dúshlán suntasach é bunú na gcaighdeán timpeallachta seo, nó spriocanna, agus soláthar de chruthúnas go bhfuil siad á mbaint amach.

Tá ionadaíocht ag Teagasc ar an nGrúpa Forfheidhmithe agus beidh sé i gcomhar agus i gcomhoibriú le geallshealbhóirí chun fís *Food Harvest 2020* a bhaint amach.

An tOllamh Gerry Boyle
Stiúrthóir Teagasc

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T News

Researcher profile

Dr Eimear Gallagher

Dr Eimear Gallagher is a Senior Research Officer at Teagasc Food Research Centre, Ashtown, Dublin 15. Since joining Teagasc, she has been involved in 14 funded projects in cereal research, co-ordinating nine of these. Her research focuses on the study of rheology, structure and macromolecular properties of novel ingredients and cereal-based formulations. She also has ongoing R&D contracts with the cereal and bakery industry. Eimear graduated from the National University of Ireland, Cork, in 1997 with a BSc in Food Science and Technology, and received an MSc in 2000. She completed a PhD in 2005 on 'The impact of ingredients on the fundamental rheological properties, microstructure and overall quality of gluten-free bread'. As a result of her PhD, Eimear was invited to be a member of the scientific and organising committee of the First International Conference on Gluten-free Cereal Products and Beverages, which was held in 2007. In 2009, her book *Gluten-free Food Science and Technology* was published by Wiley-Blackwell.

Current projects include: Healthy cereal-based snacks from by-products of the milling, malting, brewing and cider industries; Healthy cereal-based snacks for the elderly; Gluten-free baked products with enhanced sensory and nutritional properties; and, Development of a bioactive bread enriched with seaweed and buckwheat protein and peptides fractions with potential heart-health effects.

Eimear's research has been published in a number of peer-reviewed journals, including: *Cereal Chemistry; Journal of Food Engineering*; *Trends in Food Science and Technology*; *Food Chemistry*; *Journal of Cereal Science*; and, *International Journal of Food Sciences and Nutrition*.

She has contributed to a number of national and international conferences, and written articles for local and national press, including the *Irish Examiner* and *The Irish Times*. She has also made a number of appearances on television and radio.

Eimear has a keen interest in sport, and has played camogie with her home club, Bandon, and also with UCC and Cork. She is also involved in Ashtown's mixed tag rugby team.

Teagasc appointments

The Teagasc Authority recently made two appointments in the recently formed Crops, Environment and Land Use Programme. John Spink (left) was appointed Head of the Crops Science Research Department and Dr Rogier Schulte was appointed Head of the Environment, Soils and Land Use Research Department.

APC hosts 'Halloween Retreat'

Over 120 scientists and medics attended the Alimentary Pharmabiotic Centre (Science Foundation Ireland-funded Centre for Science Engineering and Technology – with staff at University College Cork and Teagasc Food Research Centre, Moorepark) 'Halloween Retreat' hosted in Moorepark on October 22. The morning sessions focused on glycobiology and metagenomics, and the afternoon sessions focused on the platforms, tools, techniques and technologies available within the Centre. The event was attended by APC staff from Teagasc, University College Cork and Cork Institute of Technology, as well as visitors from the National University of Ireland Galway, Food for Health Ireland and Cork University Hospital.

Dairy Expansion Activation Group

Dr Pat Dillon, Head of the Animal & Grassland Research and Innovation Programme, Moorepark, has been appointed to the Dairy Expansion Activation Group by the Minister for Agriculture, Fisheries and Food, Brendan Smith, TD. This group will play a key role in the move to implement the expansion in milk production envisaged in the Department of Agriculture, Fisheries and Food's *Food Harvest 2020* report.

GME2010

Dr Paul Cotter, Teagasc Food Research Centre, Moorepark, will deliver a keynote lecture on the 'Use of Bacteriocins and Bacteriocin-producing Probiotics to Modulate the Gut Microbiota in a Beneficial Way' at the International Scientific Conference on Gastro-Intestinal Microbial Ecology in the Slovak Republic in November.

China symposium

Dr Helen Grogan, Horticulture Development Unit, Teagasc, Kinsealy, and Dr Kieran Jordan, Teagasc Food Research Centre, Moorepark, were invited to speak at the International Symposium on Quality and Safety of Agri-Products, which took place in Shanghai, China, in October.

Teagasc in *ArcNews*

An article co-authored by the Teagasc Spatial Analysis Unit's Réamonn Fealy is the first from an Irish organisation to be featured in *ArcNews*, an international publication on mapping and geographic information system (GIS) technology. See: www.esri.com/news/arcnews/fall10articles/files/arcnews32_3/pageflip.html.

Agri-Environment Conference

Pictured at the Teagasc Agri-Environment Conference are (from left): Duncan Stewart, Broadcaster (keynote speaker); Professor Gerry Boyle, Teagasc Director; Liam Fahey, Department of Agriculture, Fisheries and Food; and, Mark Gibson, Teagasc, Athenry.

"As custodians of the countryside every farmer knows that it is in their interest to protect water, soil and air quality as well as enhance biodiversity. Any future expansion of Irish agriculture must take place in an environmentally sustainable manner. In Teagasc, we believe that a productive agri-food sector can co-exist with nature in a sustainable manner," said Professor Gerry Boyle, Teagasc Director, at the recent Teagasc Agri-Environment Conference.

Grasses for the Future

There are huge opportunities to grow and utilise more grass in Ireland. A Teagasc-organised international conference, 'Grasses for the Future', in October heard how grass dry matter production can be increased using newer grass varieties.

International grass breeders outlined how up to 18.5 tonnes of grass dry matter per hectare can be produced annually. Currently in Ireland we utilise about 7.9 tonnes of grass dry matter per hectare on dairy farms, with lower amounts utilised on beef farms.

AESI Young Researcher Seminar

A paper entitled 'A structural analysis of GHG emissions and the food-supply chain in Northern Ireland' won Erin Smith-Minihan the Bob O'Connor Prize at the Agricultural Economics Society of Ireland (AESI) Young Researcher Seminar recently.

Pictured at the seminar are (from left): Dr David Stead, School of Agriculture, Food Science and Veterinary Medicine, UCD; Dr Mary Keeney, The Central Bank and Financial Services Authority of Ireland (both judges of the competition); Dr Cathal O'Donoghue, Head of the Rural Economy and Development Programme, Teagasc; winner Erin Smith-Minihan (Queen's University Belfast); and, Trevor Donnellan, Teagasc.

Erin is a Teagasc Walsh Fellow supervised by Dr Ziping Wu (QUB) and Trevor Donnellan, Rural Economy and Development Programme, Teagasc.

Teagasc Science Week 2010

The aim of Science Week (November 7-14) is 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 the economy. Teagasc supports this Discover Science and Engineering initiative by holding a series of events nationwide.

The theme of the 2010 Teagasc Walsh Fellowship Seminar is 'The Walsh Fellowship Scheme's contribution to delivering the overall vision for the agri-food sector outlined in the Department of Agriculture, Fisheries and Food's *Food Harvest 2020* report, i.e., Act Smart, Think Green and Achieve Growth'. The seminar, which takes place during Science Week, provides a unique opportunity for the Walsh Fellows, Teagasc and their third-level partners to showcase the knowledge outputs and potential impacts of the scheme.

This year The Institute of Food Science and Technology Ireland has donated a President's medal for presentation to the best food science and technology presentation at the Seminar. The overall winner of the oral presentations will receive a medal from the RDS.

The guest speaker is Professor Gerald Fitzgerald, Professor of Food Microbiology, UCC. For more see www.scienceweek.ie.

Feeding the world in 2050

DR LANCE O'BRIEN describes the work of the EU Standing Committee on Agricultural Research (SCAR) Third Foresight Exercise.

Agriculture faces multiple challenges over the coming decades: it must produce more food and fibre to feed a growing global population employing a reduced rural labour force, supply more feedstocks for a rapidly growing bio-energy market, contribute to economic development in the many agriculture-dependent developing countries, adopt more efficient and sustainable production methods, and adapt to climate change.

The Food and Agriculture Organisation of the United Nations has estimated that in 2050 the world will have to produce 70% more food to feed a population of 9.2 billion people with greatly increased purchasing power. Increasing population and enhanced purchasing power result in increased food intake as well as in dietary changes to include a greater intake of meat and other animal products. The potential to increase food production is significant. It is possible to increase productivity in large parts of the world. However, this will require increased inputs of water and energy, thus impacting on these scarce resources. In addition, climate change can reduce productivity by way of an increased number of extreme weather events.

SCAR foresight study

This is the background against which the EU Standing Committee on Agriculture Research (SCAR) decided earlier this year to appoint an expert group (FEG3) to undertake a foresight study that would analyse expected environmental and resource issues impacting on long-term food security and the implications for future agricultural research in Europe.

The specific objectives of the study are to:

- provide long-term assessment and analysis of expected environmental and resource issues and their meaning for future agricultural research;
- prepare the ground for a smooth transition towards a world with resource constraints and environmental limits;
- consider the role the knowledge-based bio-economy (KBBE) can play in addressing these challenges; and,
- assemble basic building blocks for a long-term vision of more resilient and sustainable agriculture systems able to feed nine billion people by 2050.

This exercise will build on the two previous foresight exercises undertaken by the SCAR and will aim to develop a systematic approach for identifying potential risks, opportunities and likely future developments and challenges for European agriculture, and the possible implications of such developments for future research policy orientation at European and Member State levels. It builds on the SCAR's commitment to execute the foresight process on a regular basis so that society might better cope with the many interlinked challenges contributing to uncertainty about the future. This foresight study involves a meta-review of regional, national and international policy documents, scientific publications and foresight studies published mainly since 2009. It particularly looks at documents with a time horizon to 2050 and with a territorial coverage of the EU. In addition, documents relating to particular global hot spots and global foresight are included.

The focus is on new insights – which can be new drivers, new dynamics, etc. – to identify potential risks, opportunities and likely future developments and challenges for agricultural research in the EU and its Member States. The key focus of the study is on those scarcities of natural resources – land, water, energy, biodiversity – that will seriously impact on future food security. The EU 2020 strategy (Europe 2020 – A European strategy for smart, sustainable and inclusive growth) identifies pressure on natural resources as one of the three long-term challenges confronting the Union, the others being globalisation and ageing. One of its seven flagship projects is 'Resource Efficient Europe', which aims at decoupling economic growth from the availability of resources.

Disseminating new technologies

Public and private agricultural research and extension are essential for introducing and disseminating new technologies that can enhance agricultural productivity in a sustainable way. This will require a new focus for agricultural research, and Europe has a responsibility and the capacity to take a lead role in providing a range of scientific solutions to mitigate potential food shortages without adverse environmental impact and without having to bring significantly more scarce land into cultivation. This will require a new focus for European research policy and new priorities for agricultural research. The FEG3 Report will identify the necessary changes and feed them into the upcoming debate on the development of the Eighth Framework Programme.

For more information see:
http://ec.europa.eu/research/agriculture/scar/foresight_en.htm.

Dr Lance O'Brien is Head of the Teagasc Foresight Unit and a member of the Third SCAR Foresight Expert Group.
E-mail: lance.obrien@teagasc.ie.

T Feature

Building the European knowledge-based bio-economy

A recent EU conference reviewed the major achievements of, and the challenges facing, the knowledge-based bio-economy. It also agreed eight recommendations, which were issued in a report.

The European knowledge-based bio-economy (bio-economy for this article) is estimated to be worth over €2 trillion. It employs around 22 million people, and the prospects for growth are good. Senior scientists, stakeholders and European and national policymakers discussed the drivers of the bio-economy at a recent conference held in Brussels. Teagasc was represented at the conference by Professor Gerry Boyle, Director of Teagasc and Dr Lance O'Brien, Head of the Foresight Unit.

Addressing the conference, EU Commissioner for Research, Innovation and Science, Máire Geoghegan-Quinn, said: "The Belgian Presidency and the Commission are in complete agreement about the need for a more coherent approach to the bio-economy in the EU, and this conference is an important step. The bio-economy has the potential to address many of the things Europeans care most about: food security; reducing the environmental impact of agriculture and industry; providing healthy food at affordable cost; supporting coastal and rural development; and, reducing and recycling of bio-waste". However, research policy in this area is fragmented between Member States. The European Commission wants to increase coherence at both European and national level, with a stronger engagement of end-users, so that new ideas can be brought more rapidly to the marketplace and social challenges effectively addressed.

Recommendations

1. **Need for an integrated policy for the bio-economy**
   To achieve a competitive European bio-economy, broad approaches, such as creating and maintaining markets for environmentally sustainable products, will need to be combined with shorter-term measures designed to reward environmentally sustainable technologies.
2. **Research and innovation**
   The level of research and development funding in the bio-economy should be increased through multi-disciplinary research programmes at both national and EU level. Co-operation between private and public sectors should also be a focus for further improvement.
   The report calls for special attention to be paid to certain specific areas of research. One of the areas identified for special focus is the development of efficient and robust enzymes for the conversion of lignocellulosic material. The report also notes the major challenge of translating research into products, and advocates the setting up of public–private partnerships for both the pooling of resources and the setting of more ambitious goals.
3. **Towards economically sustainable and innovative SMEs**
   The report identifies the key role of high-tech small and medium sized enterprises (SMEs) in the development of technology and knowledge. The difficulty for some of these firms in getting access to finance for their research is a barrier to progress. Therefore, the report calls for grants to be made available to such firms for 'Proof of Concept' studies, and recommends supporting these firms to participate in open innovation programmes.
4. **Communication and education**
   Multi-disciplinary education, including international training programmes and efficient lifelong learning, is seen as a key factor in supporting an effective multi- and inter-disciplinary workforce.
   Therefore, a strategy for communication and stakeholder involvement is necessary.
5. **A strong EU common policy for agriculture – a new CAP (post 2013)**
   It is essential that the new CAP ensures balanced access to raw materials for the food and feed sectors, as well as for industrial applications, without disrupting food supply. It should also address situations of extreme price volatility.
6. **Support low-carbon renewable-based production systems**
   Governments aiming to support biorefineries for reasons of environmental sustainability and energy security will need to support these projects and regulate the market to stimulate private sector investment.
7. **Policies stimulating the market for bio-economy products**
   Decision makers can help by implementing a regulatory framework of incentive-based and demand-stimulating policies. The European Commission's Lead Market Initiative for bio-based products is one example of a relevant scheme and it should be further developed.

8 **Science-based sustainability criteria**
   Sustainability criteria addressing bio-economy sectors should aim to measurably reduce the key impacts associated with feedstock production, consumption and use.

Supporting European science policy

CATRIONA BOYLE reports on a recent visit to the European Commission's Joint Research Centre in Ispra, Italy.

"As a Directorate-General of the European Commission, the Joint Research Centre (JRC) provides customer-driven scientific and technical support to Community policy making," says David Walker, EU Policy Officer, JRC, Ispra. The European Commission's JRC has seven scientific institutes, located at five different sites around Europe. The site in Ispra, Italy, is home to four of these institutes.

"JRC's vision is to be a trusted provider of science-based policy options to EU policy makers to address key challenges facing our society, underpinned by internationally recognised research," said Mr Walker.

The JRC, with a staff of around 2,750, is allocated an annual budget of around €330m for direct support to EU institutions from the Seventh Framework Programme. It earns up to a further 15% through contracts (participation in collaborative projects, technology transfer and work for third parties – including industry and regional authorities). Its research fields include energy, environment, transport, climate change, competitiveness, safety of food and consumer products, security, crisis management, nuclear safety and security.

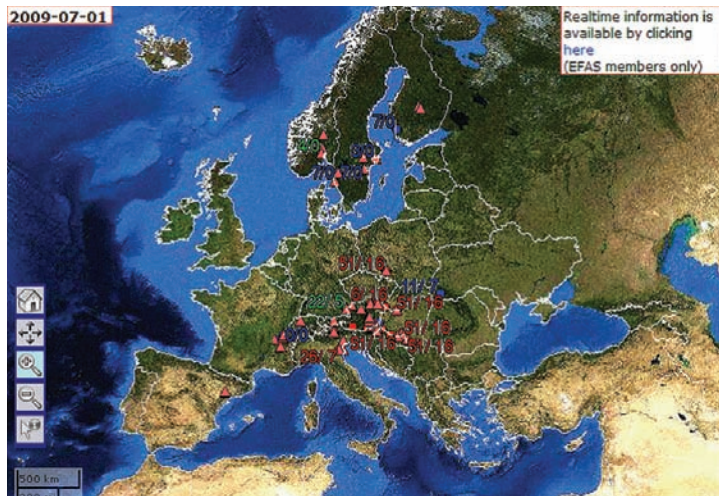
European Flood Alert System

The floods that devastated Ireland in 2009 could have been planned for if Ireland had been a member of the European Flood Alert System (EFAS), based at the Institute for Environment and Sustainability, JRC, Ispra. Ireland has not been a member of the system, mainly since such severe flooding events had not been experienced here before or, indeed, been seen by the EFAS. Ireland signed up to this system in October 2010, with the Office of Public Works as the national contact point.

Dr Ad de Roo, Action Leader of the JRC activity on floods in the Institute for Environment and Sustainability, JRC, Ispra, explains how it works. "The system uses multiple weather forecasts and other data to provide flood forecasts and warnings. The EFAS takes into account geographical data, climate conditions and rainfall estimates over the whole of Europe and helps to improve preparedness for upcoming floods by providing warnings up to 10 days in advance. Reservoirs can be opened, rescue services alerted and, if necessary, people can be evacuated in time." The technology in place at the JRC is also being used to provide long-range forecasts from months to years (e.g., for modelling climate change predictions).

Soil biodiversity

Dr Arywn Jones of the Institute for Environment and Sustainability, JRC, said that soil was our most important natural resource. Dr Jones is the lead editor of *The European Atlas of Soil Biodiversity*, which the JRC recently published. It is the first indicator-based map of potential threats to soil biodiversity. "The biodiversity within our soils plays a vital role in agriculture and in the water and carbon cycle," explains Dr Jones. The Atlas aims to support policies such as the EU biodiversity action plan, the Soil Thematic Strategy and the European Research Area. The Atlas highlights areas within Europe where soil biodiversity is most at risk of decline relative to the current situation – notably parts of the UK, the Benelux countries and Northern France, although there are also areas of high risk in several other Member States.



EFAS flood forecast for July 1, 2009, at 00:00 UTC. Circles and triangles represent reporting points where the different forecasts (indicated by the colour coding) exceed an EFAS warning threshold. The user can click on these points to obtain more detailed information on the timing and probability of the possible flooding.

Dr Jones said that Irish soils were generally in good condition but that carbon decline in arable soils is a key issue. "Under Cross Compliance, the Department of Agriculture, Fisheries and Food in Ireland has initiated the compulsory assessment of soil organic carbon for all farmers in continuous tillage production for six years or more. If the soil organic carbon value is less than 2%, then farmers must seek professional advice and take remedial action."

Safety of food and consumer products

"Harmonised European food safety standards respond to a pressing need to ensure that materials and technologies used in food production are safe for consumers. To obtain standards agreed at a European level, JRC scientists offer competences for the standardisation of testing methods and models to ensure the quality and safety of consumer products," Professor Elke Anklam, Director of the JRC's Institute for Health and Consumer Protection, explains. As a result, the same testing standards can be applied in all Member States of the EU. The JRC is also maintaining a high level of expertise to swiftly react to any potential food or feed crises by developing, harmonising and implementing constantly improved test methods throughout the EU, while co-operating closely with the European Food Safety Authority.

Crop forecasting

The AGRI4CAST EU Action is centred on the JRC's crop yield forecasting system, which aims to provide accurate and timely crop yield forecasts and crop production biomass for the EU territory and other strategic areas of the world. The system contributes to the evaluation of global production in support of CAP management decisions. In view

The soils of Eurasia

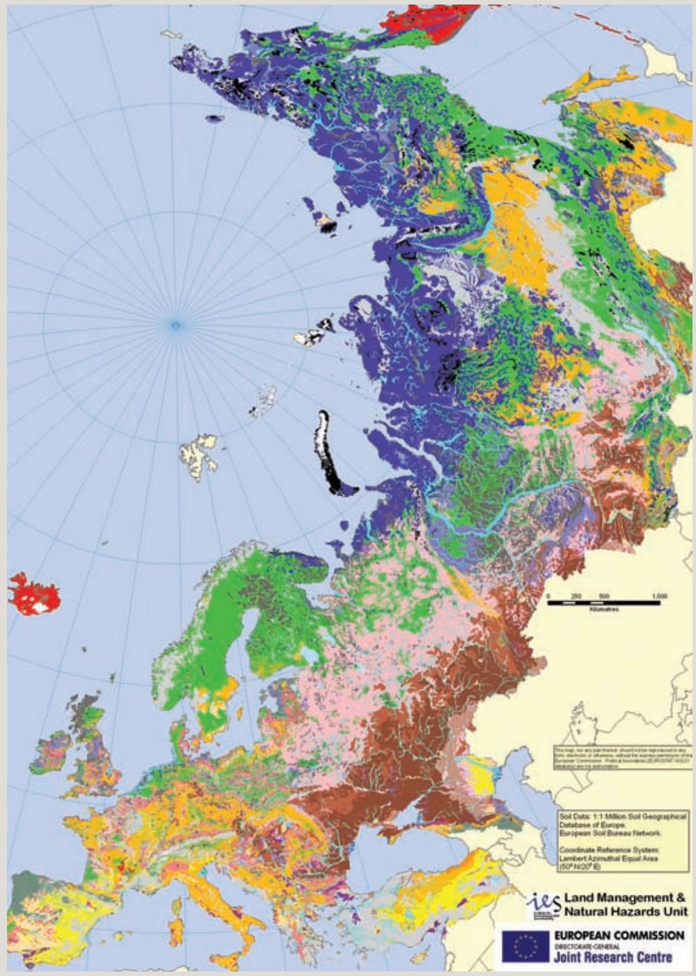
The different colours on the adjacent map highlight the variety of soil types across the European continent and into Asia. The patterns reflect the variations in the key soil-forming processes (parent material, climate, vegetation, landscape, time and human practices) with the drier and warmer conditions generally increasing southwards and eastwards.

To the east, the presence of vast flat areas (e.g., North European and Russian plains), together with a uniform cover of loose deposits, gives rise to a latitudinal pattern or zones for soil that ranges from the frozen soils in the northern tundra (dark blue), to acid Podzols under the vast boreal forests (green) and peats (olive) in wetlands. To the south, the brown colours denote fertile Phaeozems, Chernozems and Kastanozems that are characteristic of temperate grasslands (steppe). The yellows and the purple hues of the Mediterranean Basin indicate the presence of lime- and salt-rich soils in the semi-arid conditions.

Soil cover in Western Europe shows a similar zonality, which is smoothed by the diversity of parent materials and the increased influence of the Atlantic Ocean. The orange colours note the presence of relatively young or immature soils, reflecting the effect of the Ice Age. Mountains complicate the soil mosaic as they display a similar zonation of soil types, but in this case driven by altitude. The light grey tones indicate the presence of bare rock or very poorly developed soils – the line of the Alpine range stands out clearly.

There are two interesting points to note. Firstly, the bright red tones that mask Iceland, the Yakutia Peninsula in the Far East and occur as small patches in France and Italy are soils derived from volcanic deposits. Secondly, the thin turquoise strips running across the maps are soils developed on fluvial deposits (e.g., river floodplains, estuaries); these are some of the most fertile and sought after soils. The giant river systems of Central Russia are clearly visible.

This map was produced by the JRC in association with the European Soil Bureau Network, of which Teagasc is a member. Dr Rachel Creamer, Environment Research Centre, Teagasc, Johnstown Castle, is currently the Chairperson of the network.



of providing support to a reviewed CAP for the next 10 years, and the climate change policy agenda of the EC, studies on changing production scenarios based on climate change impact on agriculture will be implemented. Dr Bettina Baruth, Action Leader of AGRI4CAST at the Institute for the Protection and Security of the Citizen, JRC, said that the rationale behind the crop forecasts at EU level is based on the lack of timely information to take rapid decisions on CAP instruments during the year. "Statistics are usually provided by Member States to Eurostat and DG-AGRI with a time lag of several months relative to the harvest. This delay affects decision making in planning tools related to the CAP for the next year, as the European view is missing. The sooner this information on the harvest is available the better." AGRI4CAST has been developing and operationally running a crop forecasting system since 1992 in order to provide timely crop production forecasts at European level. This system is able to monitor crop vegetation growth (cereal, oil seed crops, protein crops, sugar beet, potatoes, pastures, rice) and include the short-term effects of meteorological events on crop production, and to provide yearly yield forecasts on European crops. Dr Baruth explained that The AGRI4CAST system, also known as the Monitoring Agricultural ResourceS (MARS) Crop Yield Forecasting System, is made by remote sensing and meteorological observations, agro-meteorological modelling and statistical analysis tools. AGRI4CAST is also used to estimate crop areas at EU level. As part of the Seventh Framework Programme, this system will be developed to include estimates of world production to provide data on main crop quantities in the export market.

> *"The specialist support provided by the JRC is pivotal as we promote growth in Europe based on knowledge and innovation. During my mandate, I want to make sure we make full use of Europe's research excellence. The JRC has a central role to play as we develop a green, innovative, sustainable economy of the future."*
> Máire Geoghegan-Quinn, Commissioner for Research, Innovation and Science

For more on the work of the JRCs see: www.jrc.ec.europa.eu.

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Growing grass for a green biorefinery – an option for Ireland?

Researchers at Teagasc and Wageningen University and Research Centre have scoped the feasibility of a green biorefinery as an alternative use of some of Ireland's grassland.

In Germany and Austria, the advanced use of biogas technologies has led to the exploration of grass as a raw material for biogas production.

Alternative use of surplus grass

The need to reduce atmospheric greenhouse gas emissions and dependency on fossil fuels has been one of the main driving forces towards the use of renewable resources for energy and chemicals. Grassland biomass is readily available since grasslands cover 26% of the land area on Earth. The integrated use of grassland biomass for the production of chemicals and energy, also known as green biorefinery (GBR), has received much attention in Europe. Over the last decade, various European countries have developed contrasting GBR systems. For example, in Germany and Austria the advanced use of biogas technologies has led to the exploration of grass as a raw material for biogas production. In Denmark, because of strict environmental controls on the land spreading of biowastes from the green crop drying industry (high temperature dried grass and lucerne, which are used as natural feeds for ruminants), GBR development originated from efforts to produce lysine from that industry's waste material.

In Ireland, approximately 90% of the 4.3 million hectares used for agriculture is under grassland and used in livestock production systems. However, the recent full decoupling of EU agricultural subsidy payments from production, together with the full implementation of the Nitrates Directive (91/676/EEC), have led to declining livestock numbers and a potential surplus of grassland biomass available for possible future GBR. The development of an Irish GBR industry is coherent with the EU Biofuel Directive (2003/30/EEC) and the EU's strategy to develop a 'knowledge-based bio-economy'. For Irish agriculture, GBR has the potential to provide supplementary income from surplus grass.

What is green biorefinery?

The basic principles of a GBR are similar to an oil refinery but, instead of oil, grass or silage is used as the raw material for the production of a variety of products. The first step in the GBR process is to separate the green biomass into the solid fraction (press cake) and the liquid fraction (press juice). The press cake consists predominantly of the fibrous part of the green biomass, whereas the press juice is a slurry of plant compounds, such as sugars, proteins, amino acids, other organic acids, lipids and minerals. Following this separation, the press juice and press cake are refined into the desired products. To date, the most successful use of press cake has been to produce insulation materials, which have comparable characteristics to the average mineral wool insulation available on the market. The press juice has been used to produce a proteinaceous product for animal feed. In addition, technologies are currently being developed at pilot scale in some European countries to extract higher value products from the press juice, such as lactic acid which is used as a building block for plastic production (polylactic acid), and amino acids which are used as ingredients for cosmetics.

A key aspect of the GBR system is the use of anaerobic digesters and combined heat and power plants (CHP) to produce biogas from the residual or waste grass/silage slurries that remain after extraction of the desired fractions from the biomass. This biogas is converted into electricity and heat, and is either used to supply the biofinery with energy, or is sold into the national electricity grid.

First generation green biorefinery for Ireland

As part of a scoping study, we collated data and knowledge from the operation of GBRs in Europe and, combined with new Irish data on grass quality, assessed the economic, technical and environmental feasibility of a GBR in an Irish context, which we used to develop the following blueprint for a first-generation GBR:

Scale

While larger GBR factories allow for economies of scale, they also require feedstock (grass) to be transported over longer distances. Our scenario analyses suggested that the ideal catchment area for a GBR was 700-800ha depending on biomass availability within the catchment area, and the availability should be in excess of 30% in order to contain transport costs. An added benefit of a decentralised GBR facility processing approximately 0.8t of dry matter per hour is that it allows for ease of operation and better knowledge of the source and quality of the herbage being supplied.

The basic principles of a GBR are similar to an oil refinery but, instead of oil, grass or silage is used as the raw material for the production of a variety of products.

Potential locations

In general, the viability of GBR will be highest in areas that have experienced declining livestock numbers and lower farm income, particularly, but not exclusively, areas that support a higher proportion of non-dairy farms. These areas have a higher potential availability of surplus grass biomass. This would mean that the GBR would not have to compete with the traditional agricultural commodities, but rather would provide potential supplementary income to farmers.

Supply chain – raw material and products

The transitional development of a GBR system is likely to be most successful if current harvesting practices (i.e., a two-cut silage system) are adopted. Our research showed that the quality of the biomass from such harvesting systems is compatible with the basic GBR technologr analyses showed that feedstock quality can be best controlled by operating a silage-only system, with on-site ensiling of the grass material at the GBR facility. The use of silage as a feedstock facilitates year-round operation of the GBR facility.

Energy

Biorefinery processes, such as fiberising (separating press cake and press juice), drying and centrifuging are energy intensive. Therefore, the viability of the GBR depends to a large extent on self-sufficiency in terms of energy requirements. This can be achieved by anaerobic digestion of the fibre slurries that remain after processing.

Nutrient cycling

The residual material remaining after the anaerobic digestion can be used as fertiliser on the farm supplying the biomass as part of a 'waste management strategy' that aims to maintain nutrient balance between the GBR and the source farms. This recycling will reduce the direct costs of the supplying farms.

Future research requirements

The blueprint outlined above provides a framework for the development of a first-generation GBR, and has identified key areas that require further research. These include improved ensiling techniques, integration of livestock farming systems and GBR systems, and nutrient budgeting of the GBR system.

A GBR project funded by the Department of Agriculture, Fisheries and Food Stimulus Fund is currently ongoing at Teagasc, Animal & Grassland Research and Innovation Centre, Grange, in collaboration with University College Cork (UCC; Dr Jerry Murphy) and Queen's University Belfast (QUB; Dr Elaine Groom). This project is investigating the uses of GBR aside from animal feeds and developing technologies for those uses. The thrust of it is to progress some of the technologies that might be involved in a biorefinery using grass as its feedstock. Thus, the following are being assessed at Grange: (a) the potential of different grass species and red clover to produce biomass either as a fresh crop or as silage; (b) the potential of these species (grown at different nitrogen fertiliser inputs and harvested at different stages of maturity) to provide fibre that could be used industrially; and, (c) the potential of these species to produce biomethane in anaerobic digestion systems. The group at UCC is developing optimal pilot-scale anaerobic digesters for producing biomethane from grass silage, while the group at QUB is investigating how alternative treatments of the silage immediately prior to anaerobic digestion could improve the biomethane yield. An economic analysis will be undertaken collectively of the various processes investigated/developed and an optimal blueprint will be identified. Finally, the information provided will be disseminated. This project has just over two years left to completion.

This study was jointly funded by the Teagasc core fund and Wageningen University and Research Centre.

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Halting biodiversity loss by 2020 – implications for agriculture

The United Nations declared 2010 to be the International Year of Biodiversity. Much of European and Irish biodiversity is an integral part of farming systems. As the European Union commits to halting biodiversity loss by 2020, JOHN FINN and colleagues indicate some of the likely implications for agriculture.

Biodiversity refers to the variation among living organisms in terrestrial, marine and other aquatic ecosystems, and includes diversity within species, between species and of ecosystems. Biodiversity is being increasingly recognised for the significant economic contribution made by its provision of ecosystem services (e.g., provision of food and fibre, regulation of climate, pollination, maintenance of soil fertility, water purification and regulation of pest populations). Alongside climate change, the loss of biodiversity is one of the most pressing global policy issues of our time. Many threatened and protected species and habitats show no sign of improving, and the threats to them are not abating. Having failed to achieve the target to halt biodiversity loss by 2010, the European Union (EU) is now preparing to strengthen its policy framework and commitment to both halting the loss of biodiversity and halting the degradation of ecosystem services in the EU by 2020, and restoring them insofar as is possible. The implications of these high-level policy commitments to protect biodiversity are evident across various sectors. As part of wider reform of the Common Agricultural Policy (CAP), biodiversity targets will feature prominently among future environmental commitments.

CAP reform and biodiversity

Recent commentary suggests that public money from the proposed reform of the CAP will be more closely linked to support the delivery of public goods, mostly in the form of environmental benefits. Halting and reversing biodiversity loss will undoubtedly be one of the specific public goods to be prioritised in the re-negotiated CAP. In addition, other public goods include the cultural heritage of landscapes, clean air, high water quality, control and prevention of fire and flooding, soil quality, reduction of greenhouse gas emissions, carbon sequestration, and others. The specific policy mechanisms and budget size for provision of public goods in the post-2013 CAP are not yet certain at either national or EU levels. Nevertheless, provision of public goods is likely to feature prominently, especially as most public goods from agriculture are threatened but remain highly valued by society. The future CAP policy on public good provision, however, is almost certain to require improved specification of policy targets, a greater level of geographical targeting and improved implementation. There is also likely to be a stronger requirement for monitoring and evaluation – to both clearly demonstrate the environmental benefits of effective measures, and identify any improvements that are required.

Ireland's rich biological heritage

Ireland has a rich biological heritage that is a legacy of generations of farming. Nevertheless, the continued protection of this biological heritage requires active management. An evaluation by the National Parks and Wildlife Service of the status of protected habitats and species (many associated with farmland) concluded that: "Many Irish species of fauna and flora have a moderately satisfactory status, but a small number are in urgent need of concerted efforts to protect them. The assessments of habitats present a much bleaker picture, with the majority being rated as having poor or bad overall status" (NPWS, 2008). Restoring species and habitats to favourable conservation status will be a priority action in the years ahead. Examples of such species and habitats include freshwater pearl mussels, the natterjack toad, Atlantic salmon, raised bogs, blanket bogs, old oak woodlands and yew woodlands.

Conservation goals

Biodiversity conservation goals will not be achieved solely by protecting particular habitats or species, as under the Natura 2000 network of designated sites. As a consequence, the conservation of biodiversity in the wider countryside outside of designated sites is a specific policy objective. To this end, high nature value (HNV) farming and forestry systems are prioritised in EU and national policy goals for biodiversity. These systems can be found in designated sites, but are also widespread in other (undesignated) areas of countryside. All Member States were required to identify HNV farmland, and target agri-environmental payments towards them, by 2008. The national-scale spatial distribution of undesignated HNV farmland and farming systems is a significant knowledge gap and considerable work remains to fully incorporate HNV farmland into agri-environment policy and practice (e.g., The Heritage Council, 2010). Many parts of Ireland (especially in the uplands and on the western seaboard) would be considered to be HNV farmland, and farmers in these areas find it hardest to maintain viable incomes. The targeting of payments towards more environmentally valuable systems would promote the economic viability of such HNV farming systems, and ensure the delivery of public goods.

Far left (top): The Irish countryside provides a mixture of food production, wildlife habitats and other environmental services. Payments for environmental services will be a key focus of negotiations of the post-2013 CAP.

Far left (bottom): The native red squirrel is threatened by the poxvirus carried by the invasive grey squirrel. Invasive species are a major and increasing threat to biodiversity.

Left: High nature value farming systems in the wider countryside represent key areas for the protection of habitats. Species-rich grasslands support rare orchids and bumblebees.

Agri-environment schemes

Agri-environment schemes (e.g., the Rural Environment Protection Scheme, the Agri-Environment Options Scheme and the National Parks and Wildlife Service Farm Plan Scheme) will continue to be important policy instruments with which to achieve biodiversity targets on designated sites and in the wider countryside. Future schemes, however, will require more specific objectives, a greater level of geographical targeting, improved implementation, and more effective monitoring and evaluation. Lessons from a number of recent studies indicate that halting biodiversity loss in environmentally sensitive areas will require a greater emphasis on 'deep and narrow' rather than 'broad and shallow' measures, e.g., conservation of the Kerry lily, protection of farmland birds, management of species-rich grassland systems in the Burren and elsewhere, nutrient management to protect fish species in Lough Melvin, and protection of freshwater pearl mussel populations. Not all areas or actions are of equal biodiversity value; thus, it may be useful to differentiate the relative value of different conservation approaches for halting biodiversity loss of farmland wildlife. In descending order of priority, these are broadly represented as follows:

- protection (including restoration) of priority habitats/species on Natura 2000 sites;
- protection of priority habitats/species that occur outside Natura 2000 sites;
- protection of rare and threatened species (e.g., those associated with Red Data Books, Species Action Plans, Flora Protection Orders, etc.);
- protection of other species and habitats of high conservation value;
- protection of species that are declining, but are not yet rare;
- protection of other common farmland habitats and species;
- creation of farmland habitat to support named species; and,
- creation of common farmland habitats.

The Rural Development Plan and agri-environment schemes in Ireland will contribute to achieving the objective of halting biodiversity loss. Achieving this will likely result in an increased prioritisation of spatially targeted and evidence-based measures aimed at named species and habitats that are of highest conservation concern. The greatest challenge will be the availability of sufficient funding to address these and other public good targets. With these and other issues in mind, the outcomes of the current CAP reform will be closely watched.

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Mushroom virus X disease: a whiter shade of pale brown?

Mushroom virus X (MVX) is a disease that affects the white cultivated mushroom, *Agaricus bisporus*, by causing brown or off-coloured mushrooms to occur in white strain crops. Researchers at Teagasc and AFBI are investigating some of the key factors responsible for this complex disease.

Mushroom virus X (MVX) is a disease that affects the white cultivated mushroom, *Agaricus bisporus*, by causing brown or off-coloured mushrooms to occur in white strain crops. These and other symptoms, such as crop delay, poor quality mushrooms and yield loss, were first observed on English farms in the mid 1990s, but by the late 1990s Irish and Dutch growers were also reporting similar symptoms. Analysis of symptomatic mushrooms identified many double-stranded ribonucleic acids (dsRNAs), which are characteristic of fungal viruses, indicating a likely viral cause of the problem.

In Ireland, the most commonly observed symptom of MVX disease is the presence of brown and off-coloured mushrooms in white strain crops, and these symptoms continue to occur on a regular basis every year. However, the expression of these 'brown mushrooms' in crops is transient and inconsistent. Symptoms may appear in one growing room on a farm and not in others, or in one flush of a crop but not in the next. The numbers of mushrooms affected can be either very small and insignificant, or whole crops may suffer, causing disruption to the mushroom supply chain and economic losses for the grower. As 80% of Irish mushrooms are exported, it is important to get to grips with this disease to ensure the consistent production of high-quality mushrooms. The epidemiology and aetiology of this new disease is poorly understood. Research at Teagasc has focused on understanding how MVX spreads within and between crops so that steps can be taken to control it and eliminate it from mushroom production. One aspect of our current research has been to focus on identifying the factors that influence the expression of symptoms, and to do this a reliable diagnostic test was needed to detect the viral dsRNAs associated with the symptoms.

The Irish mushroom industry has a farm gate value of around €100 million per annum, of which about 80% is exported to Britain. Losses due to MVX can reach 1% per annum, although individual growers will suffer higher losses. Outbreaks of MVX cause reduced efficiency and disruption to the supply chain, as well as product rejection at the destination as some infected mushrooms only develop symptoms in transit.

Detection

Brown and off-coloured MVX-infected mushrooms are consistently associated with the presence of a small number of low molecular weight dsRNAs of between 0.6 and 2.0 kilo base pairs (kbps); therefore, in order to detect the presence of the disease we have to be able to detect some of these associated dsRNAs. We developed a polymerase chain reaction (PCR)-based molecular method to detect one of these (which is always present in brown infected mushrooms), a 1.8kbp dsRNA, in mushroom samples. We also developed a modified test for compost samples, as the virus dsRNA can also be present in the mushroom mycelium that colonises the compost before the mushrooms are produced. However, mushroom compost contains humic substances and phenolic compounds that interfere with molecular reactions, so testing compost samples is inherently less effective due to false negative results. A definite positive result for compost is nonetheless a great aid to determining if the virus is present at this stage of the process. Future work will aim at improving the efficiency of diagnostic tests on compost samples.

White or brown?

One of the difficulties encountered when trying to assess whether a mushroom crop is infected with MVX is trying to determine whether or not the mushrooms are showing the characteristic 'brown' symptom. Symptomatic mushrooms can range in colour from dark brown to off-white, making visual assessment by eye very difficult. A quantitative method of colour determination was needed and a Minolta CR-200 chromameter was used to quantify the colour of mushrooms from various experiments.

The chromameter data gave a better understanding of the variability of brown mushroom symptom expression following the infection of crops. Good quality white mushrooms had a delta-E value (ΔE) in the region of 8 to 12 with a low level of statistical variance (**Figure 1**). Mushrooms from virus-infected crops, however, showed a very broad range of delta-E values (8 to 20+) with a high level of statistical variance (**Figure 2**). In terms of brown colour expression, it was only when the delta-E was 15 to 20 that the mushrooms appeared 'pale brown' to the naked eye, and when the delta-E was 20+ the mushrooms were a more noticeable darker brown colour. However, many mushrooms from infected treatments had delta-E values of <15 and these appeared white to the naked eye, yet when tested were shown to be virus infected. Thus, although there was great variability in terms of the brown colouration symptoms, all mushrooms from infected plots were infected, not just the visibly brown ones.

The chromameter data also identified and quantified an additional complexity to the characterisation of colour. In those crops where brown mushroom symptoms (and/or large delta-E variability) were found, symptoms were often confined to only one week's harvest (equal to one flush of mushrooms). Other flushes either before or after the flush with symptoms frequently gave delta-E values very similar to the controls, yet these non-symptomatic mushrooms still tested positive for the presence of the virus (**Figure 3**).

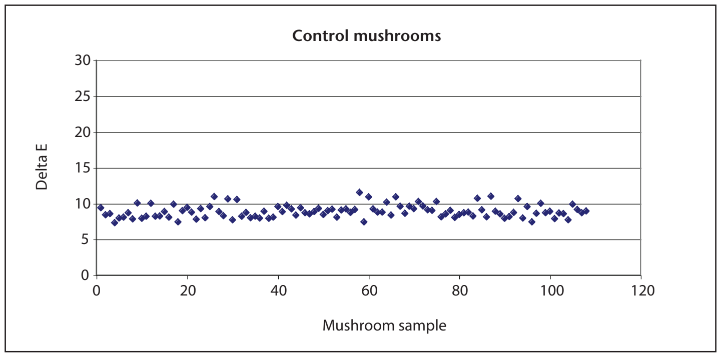

FIGURE 1: Range of delta-E values in control mushrooms.

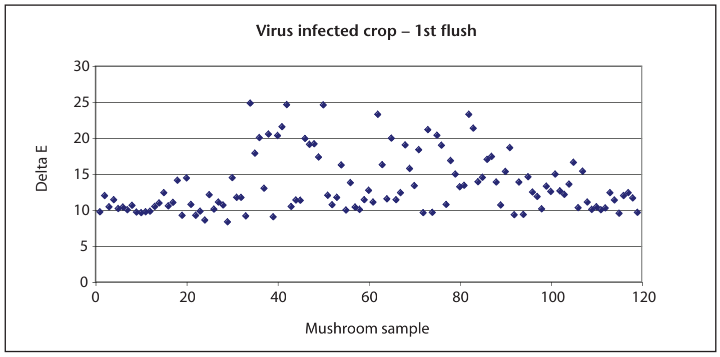

FIGURE 2: Range of delta-E values in the virus-infected crop – first flush.

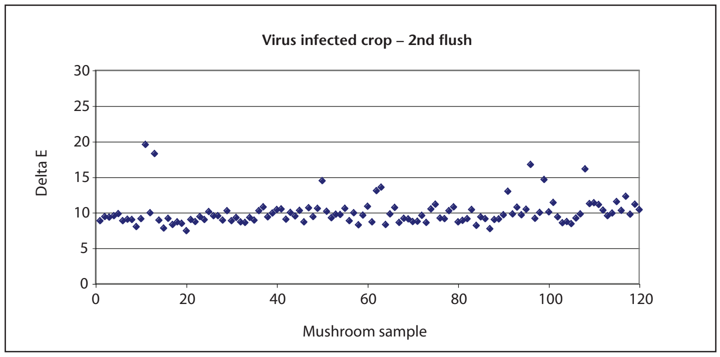

FIGURE 3: Range of delta-E values in the virus-infected crop – second flush.

Time of infection

Repeated experiments demonstrated clearly that the time at which a crop was infected with virus was very important in terms of whether or not symptoms were observed. Crops infected at the start of the crop cycle when the mushroom mycelium is first introduced into the compost frequently showed no brown mushroom symptoms and no variability in delta-E values, whereas crops infected 17 days later when the compost was fully colonised by mushroom mycelium invariably did develop brown mushroom symptoms in one or more flushes. Thus, crops can be fully infected, show no symptoms and cause no concern to the grower. Such crops, however, would ultimately produce infected mushroom spores and infected mycelium on the grower's farm, awaiting an opportunity to infect a crop at a later stage of development, which could then result in the brown mushroom symptoms developing.

Agronomic factors

Several research experiments were conducted in conjunction with the Agri-Food & Biosciences Institute, Northern Ireland (AFBI-NI), to explore the hypothesis that the brown mushroom symptoms are either directly caused or made worse by a combination of growing factors (such as compost fill density, casing management and watering regimes) that reduced the evaporation potential of a crop – a theory supported by some in the industry. All research experiments indicated, however, that the brown mushroom symptoms only occur when virus-infected material had been incorporated into a crop, and that agronomic factors neither cause nor exacerbate the level of symptom expression to any significant extent.

Regular testing

The regular absence of symptoms in infected crops is probably the main reason why this disease has continued to flare up on a regular basis in Ireland and elsewhere since it was first reported in the mid 1990s. There is a belief that it comes and goes from nowhere, causing brown mushroom symptoms that do not correlate with any grower or composter practices. The research data suggests, however, that it may well be present at non-symptomatic levels for periods of time. Regular testing of both mushroom and compost samples would help to establish if this is indeed the case. Future research will focus on trying to identify reservoirs of virus inoculum on compost yards and mushroom farms, and to identify routes by which such inoculum gets into the production system so that effective control measures can be put in place.

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Caoimhe Fleming-Archibald was a contract researcher and **Angela Ruggiero** was a contract technician on this project. **Mairead Kilpatrick,** Agri-Food & Biosciences Institute, Northern Ireland Horticulture and Plant Breeding Station, Loughgall, Co Armagh, Northern Ireland. **Helen M. Grogan,** Senior Research Officer, Horticulture Development Unit, Crops, Environment and Land Use Programme, Teagasc, Kinsealy, Malahide Road, Dublin 17.
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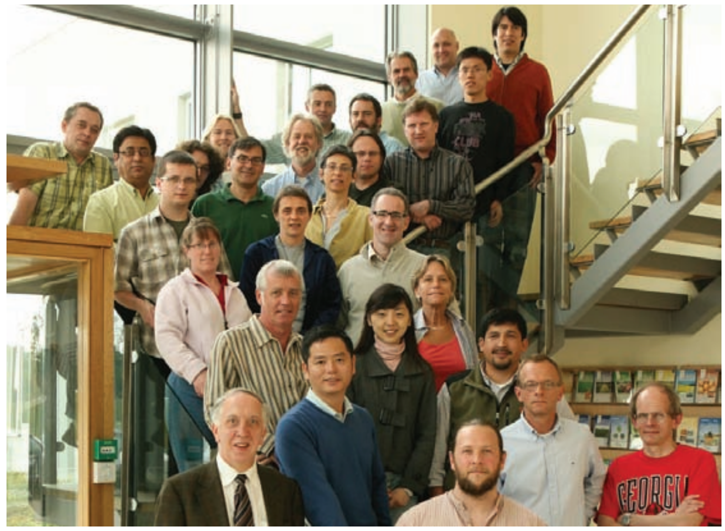
Blueprint for building a better potato

A multidisciplinary team of biologists and plant breeders at the Crops, Environment and Land Use Programme, Teagasc, Oak Park, is part of the international research consortium that recently released a draft sequence of the potato genome. The team is already exploiting the results to breed better potato varieties.

As well as its deep cultural significance in Ireland, the potato remains an important feature of our diet. Even in the face of the increasing diversity of foodstuffs available to consumers, the potato is still the staple carbohydrate source for the Irish population, with the average citizen consuming about 113kg of potatoes every year. The potato is also important in the context of global food security. After wheat and rice, potato is the third most important food crop, with a world-wide production of 325 million tonnes in 2007 (FAOSTAT). By 2020, it is estimated that more than two billion people worldwide will depend on the potato for food, feed, or income. These facts underscore the necessity for the availability of high performing potato varieties exhibiting traits such as quality, disease resistance and adaptation to a range of environmental conditions. Plant breeding is widely acknowledged as one of the most cost-effective ways of achieving these goals, which remain key objectives of potato breeding programmes worldwide. A deep understanding of the biological processes underlying these traits, and the development of advanced science-based approaches for genetic improvement of the potato, are fundamentally important to our ability to continue to breed better potato varieties.

Sequencing the potato genome

The availability of a complete genome sequence is considered a watershed moment in biology-based research for any organism. At 850 million nucleotides (letters of the genetic code), the potato genome is just over one-quarter the size of the human genome, and has a basic (haploid) chromosome number of 12. Despite its small size relative to the human genome, the task of generating, and subsequently analysing, this much DNA sequence information presented a challenge too great for any single research group to carry out. Therefore, in 2005, researchers at Wageningen University in the Netherlands initiated the formation of an international consortium of potato genetics research groups whose goal would be to elucidate the near-complete DNA sequence of the potato by 2009. The Potato Genome Sequencing Consortium (PGSC) has since grown to include 16 research groups from 14 countries around the world, including the group at Oak Park.



Members of the Potato Genome Sequencing Consortium at a visit to the Crops, Environment and Land Use Programme, Teagasc, Oak Park.

Next generation sequencing

The project began by adopting the well-established strategy previously used to sequence the human genome and, subsequently, the genomes of the plant species *Arabidopsis thaliana* and rice. This approach involves the painstaking identification, isolation and sequencing of approximately 800 'chunks' of potato DNA (each approximately 100,000 nucleotides long) spanning each chromosome. Research groups committed to sequencing individual potato chromosomes, with the Oak Park group, in conjunction with colleagues at the Scottish Crop Research Institute in the UK, targeting potato chromosome IV. During the course of the project, this laborious approach was superseded by rapid advances in DNA sequencing technology, driven by incentives such as the $10 million Archon X prize, which will be awarded to the first group to sequence 100 human genomes within 10 days or less at a cost of no more than $10,000 per genome. This drive has resulted in the availability of a host of 'next generation sequencing' (NGS) technologies, and the potato genome project was completed by adopting a combination of NGS approaches with more traditional sequencing methods. NGS methods also allowed a switch to a faster 'whole genome shotgun sequencing' approach, in which the entire genome was broken into fragments as small as 35 nucleotides and reassembled using the enormous computing capacity available at the Beijing Genomics Institute in China, where most of the shotgun sequencing was also performed.

Public access to sequence

The first version of the draft sequence of the potato genome was released into the public domain in September 2009. This means that the basic sequence information can be downloaded by anyone with a good internet connection, with relatively few restrictions on the use of the data. Since the release of the sequence, PGSC partners have continued to work to make it a useful resource by identifying the organisation and expression patterns of the majority of the potato's approximately 45,000 genes. One central goal of the PGSC is to render the potato genome sequence as useful as possible to those in the scientific and breeding communities. To this end, various PGSC partners are in the process of developing web-based tools that will allow anyone who is interested in the data access to both the DNA sequence and the arguably more important information of gene organisation and expression (**Figure 1**). This emphasis

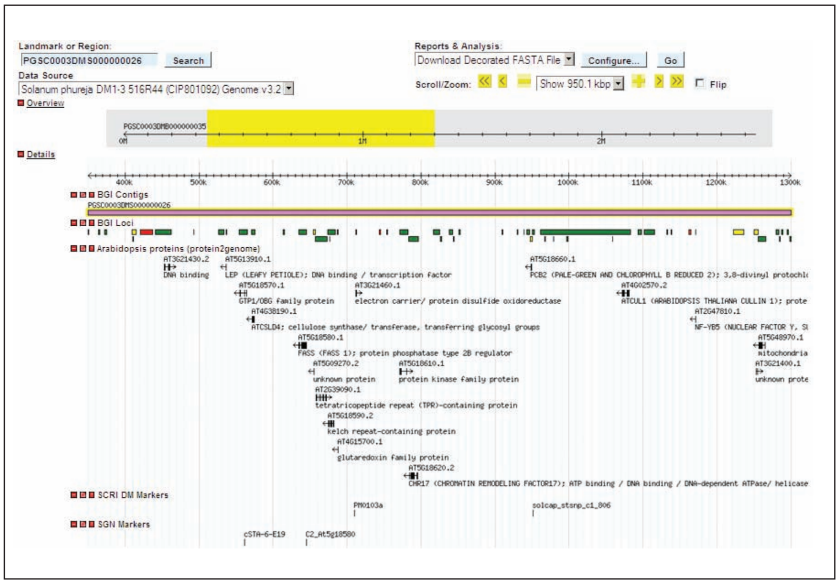


FIGURE 1 (left): A screenshot of the Potato Genome Browser, one of the publicly accessible web-based resources being developed by PGSC partners at Michigan State University. The image shows the gene content of a one million nucleotide long region of the potato genome. (Image courtesy of B. Whitty and R. Buell, MSU.)

FIGURE 2: One of the genetic fingerprinting-based assays developed for the genome sequence information at Oak Park allows potato breeders to easily predict the resistance status of 12 potato lines from the breeding programme. In this polymerase chain reaction (PCR)- based assay, resistant breeding lines (R) exhibit a band, while susceptible (S) lines do not.

on public accessibility of the sequence information is an important facet in maximising its utility for breeding and genetics research.

Sequences important for disease control

A major focus of the Teagasc contribution to the sequencing initiative has been the development of a high quality sequence of a region of potato chromosome IV, which harbours a cluster of genes conferring resistance to important potato pests and diseases, such as late blight and potato cyst nematodes (PCNs). Worldwide, late blight alone is estimated to cost potato producers a combined figure of nearly €5 billion in control measures and crop losses (Haverkort *et al.*, 2008). More recently, in Ireland, the issue of varietal resistance to late blight has become a hot topic with the emergence of new, more aggressive strains of the disease that have rapidly spread across the country over the last two to three years. These new blight strains are characterised by the ability to infect varieties that had previously exhibited high levels of resistance to the pathogen, a reduced sensitivity to some fungicides, and a new danger of earlier blight infections from over-wintering oospores in the soil (a problem not yet experienced in Ireland). These challenges mean that developing new disease-resistant varieties has become an even more important goal in potato breeding at Oak Park.

Breeding for disease resistance

The earliest DNA sequences generated by the Oak Park team in this important disease resistance region have been used to develop genetic fingerprinting tests that can identify potato varieties and breeding lines that possess a gene conferring resistance to PCN. This is probably the second most significant potato pathogen worldwide, and its persistence in the soil is one of the main reasons why potato growers require such long rotation periods relative to many other crops. The breeding team at Oak Park now uses this fingerprinting test as a genetic marker to identify breeding lines carrying the PCN resistance gene very early on in the 15-year period required to breed a new variety, radically improving their ability to produce PCN-resistant varieties (**Figure 2**). More recently, the team has extended this fingerprinting approach (called marker-assisted selection, or MAS) to include genetic markers for resistance to late blight and potato virus Y.

Benefits to industry

The availability of the draft sequence of the potato genome will radically enhance our ability to dissect the genetic basis of many of the biological processes important in the potato. This will allow cutting edge breeding strategies such as MAS to be applied to selection for a host of desirable traits in the potato, including many of those that will become increasingly important in the face of challenges such as climate change and the necessity for reduced inputs of agrochemicals and carbon in the potato production cycle.

More information on the PGSC and the draft sequence of the potato genome can be found at the PGSC homepage: http://www.potatogenome.net.

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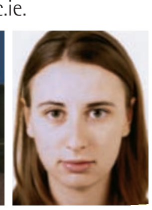
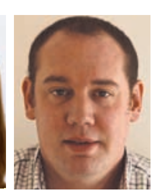


Mind the gap: deciphering the gap between good intentions and healthy eating behaviour

The intention–behaviour gap is being studied by researchers at Teagasc Food Research Centre, Ashtown, in conjunction with UCC, in order to gain an improved understanding of consumer behaviour in relation to healthy eating.

We regularly hear how the best of intentions do not translate into action. This is nowhere more apparent than in the case of healthy eating, where many fall through the gap between intention and action. Research is ongoing at Teagasc Food Research Centre, Ashtown, and University College Cork to try to decipher this intention–behaviour gap in relation to healthy eating in order to achieve a better understanding of consumer behaviour in relation to health and nutrition. This understanding addresses a very important objective for national policy makers as well as for the food industry in Ireland and the EU.

What is good behaviour?

Healthy eating is often regarded as a 'self-directed' health behaviour, given that individuals can contribute to their own health and well-being through adopting particular health-enhancing behaviours and avoiding health-compromising behaviours. Many theories and models exist that try to explain how, why and in what way people engage in a particular behaviour. One such model that has been used very widely and successfully in the areas of marketing and health behaviour is the Theory of Planned Behaviour (TPB), which links attitudes with intentions and behaviour (Ajzen, 1991). It is based on the premise that a person's behaviour is very strongly influenced by their intentions to perform that behaviour. The intention to perform the behaviour is based on the person's attitude to the behaviour (positive and negative attitudes), their norms (whether this behaviour is acceptable or not) and perceived control (if they believe they have the ability to carry out the behaviour) (**Figure 1**). However, the TPB does not take into account the 'leaky pipeline' between intentions and behaviour. Self-regulation plays a very important role in health behaviour. It involves setting goals, and monitoring and appraising these goals. Two phases of self-regulation behaviour have been identified as the motivational phase (when the individual weighs up the costs and benefits of performing the behaviour) and the volitional/post-intentional phase (when the individual develops plans to carry out their intention). Much research to date has focused on the factors that influence the motivational phase of self-regulation while neglecting the post-intentional phase. However, in order to explain this intention–behaviour gap, it is argued that the self-regulatory view of behaviour needs to go beyond the strength of a person's motivation towards a behaviour and examine in more detail the factors that influence the post-intentional phase of behaviour.

What leads to good behaviour?

The National Adult Nutrition Survey (NANS) was recently completed on a representative sample of 1,500 Irish adults, and collected a range of data on food consumption, food choice and body measurements. Additional qualitative in-depth interviews were conducted on 80 of these adults. In these in-depth interviews, participants gave accounts of their food choice strategies/goals and successful/failed attempts to make changes. It is this element of the discourse that was of interest to the current study. Twelve of these interviews were purposefully mined to identify all discourse around intention and behaviours. Expressions of ambivalence and satisfaction regarding current and past dietary behaviours were sought out. The sources of the ambivalence/satisfaction were considered in the context of level of goal achievement and behaviour.

Analysis of the interviews identified three important factors that mediate the intention–behaviour relationship, namely, planning, coping/control and monitoring (**Figure 2**). Firstly, forming behavioural plans is an important determinant of achieving the behaviour. This is particularly true for behaviour change efforts, for example, when people are trying to improve the health quality of their diet. There is a view that was frequently put forward in the interviews that there is an association between

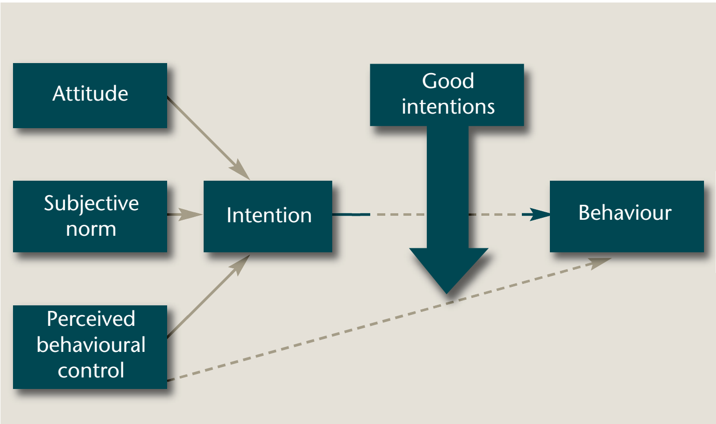

FIGURE 1: Ajzen's Theory of Planned Behaviour with the intention gap illustrated.

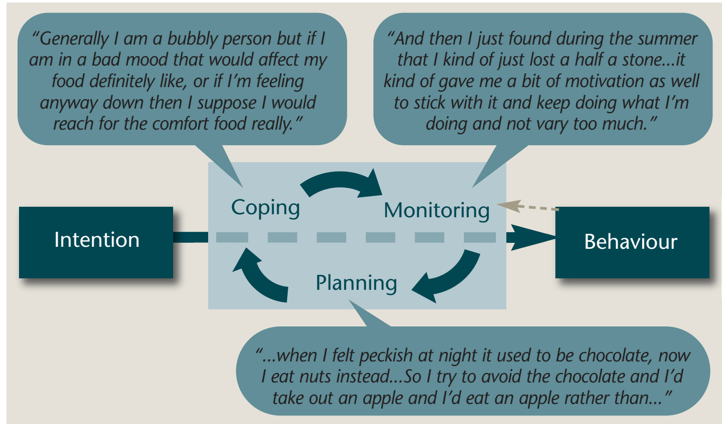

FIGURE 2: The three constructs of planning, coping/control and monitoring that bridge the gap between intention and behaviour.

eating healthily and being prepared or planning meals in advance. For example, one woman explained how she copes with temptations to consume foods that she would rather not have in her diet:

"...I'm very aware of not letting something like sweets creep in, so sometimes I get the light polo mints just to have something sweet and try and make do on something like that".

Good behaviour is also more likely when people notice positive results from their goal striving activities. For example, a female respondent talked about the results that she noticed from making some dietary changes and this reinforced her motivation to continue with the dietary changes she was making:

"And then I just found during the summer that I kind of just lost a half a stone ... it kind of gave me a bit of motivation as well to have, stick with it and keep doing what I'm doing and not vary too much".

Finally, people need to believe in their capability to maintain commitment to a goal/intention even in the face of obstacles and failures. From the analysis of the interviews, it is clear that there are times when individuals make food choices that are not in line with their dietary motivations. For example, one woman explained how a feeling of stress resulted in food choices that she would rather not have in her diet:

"...if I'm under pressure and a lot going on I would tend to ... to give in."

How to bridge the gap?

The three constructs of planning, coping/control and monitoring can help in bridging the gap, as illustrated in Figure 2. People who plan ahead are more likely to successfully carry out their good intentions compared to those who do not form plans. Furthermore, individuals need to appraise and monitor their goal striving activities in order to realise their good intentions. This has a feedback mechanism with behaviour. Control and coping mechanisms are essential to maintain effort and good behaviour when faced with obstacles and temptation. These observations reinforce the view that maintaining healthy weight in an obesogenic environment requires more than instinct: it also requires intellect, i.e., a conscious effort (Peters *et al*., 2002).

Benefits and further work

The findings from this research are in keeping with evidence presented within the research literature and one can conclude that planning, monitoring activities, and coping/self-control are three important features in the transitional space between behavioural intention and behavioural action. A deep understanding of these concepts is undoubtedly important when attempting to facilitate health behaviour change efforts. These three concepts should be considered and addressed as the food industry endeavours to make the healthy choice the easy choice for consumers.

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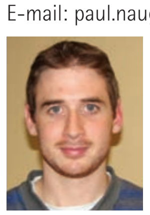

The infant formula sector in Ireland

Teagasc has played a central role in the development of the thriving infant milk formula sector in Ireland through research at Teagasc Food Research Centre, Moorepark. MARK FENELON and PHIL KELLY explain recent research advances in this area and its importance in this highly competitive sector.

The global market for infant milk formula (IMF) is estimated to be worth US$5-6bn, with Ireland producing in the region of 10-15% of global exports. Three of the major infant formula manufacturers, i.e., Abbott, Danone and Pfizer, have processing facilities located in Ireland. In fact, Ireland is host to one of the largest infant formula manufacturing plants in the world – the Pfizer plant located in Askeaton, Co Limerick. It is clear that the infant formula sector plays a significant role in the Irish dairy industry as a large consumer of milk and high quality dairy ingredients. The scale of operation is such that the strongly branded nutritional products of the multinational companies involved provide a vital channel to market across large geographical regions for Irish dairy processors and their ingredients. However, there is concern at the increasing lack of competitiveness in the Irish economy, as it will continue to erode the long-term commitment to large volume manufacture of formula here. Internal corporate competition within multinational companies over the last decade has accelerated the development of manufacturing operations in countries like China. The latter has led to the need for developing R&D capabilities within Ireland in order to capitalise on the benefits of continuing local manufacture plants within a highly-developed knowledge economy centred around Irish scientific and technological capability.

The Teagasc research base and links with the nutritional beverage and ingredient supplier sector is already proving invaluable to new product development (NPD) groups within multinational companies. This research capability, in conjunction with the state's inwards investment policy as represented by Enterprise Ireland and the Department of Agriculture, Fisheries and Food, is helping to consolidate and expand the IMF and nutritionals sector of the food industry. Hence, the orientation of Teagasc's research direction is strategically important, as it helps to underpin the NPD capabilities of infant formula companies with respect to their manufacturing sites in Ireland. The strategy is to conduct research involving dairy companies to support a three-way relationship between IMF companies, research provider (Teagasc) and ingredient suppliers to accelerate the process of bringing innovative developments to the point of commercialisation – the ultimate step in the process at Teagasc being facilitated by applying formulation science in conjunction with a processing platform that is uniquely customised for infant formula specification.

Teagasc infant formula research

Two technological features predominate in IMF manufacture:

(i) product safety – both compositionally and microbiologically given the vulnerability of the neonate as consumer; and,

(ii) an increasing push to 'humanise' cows' milk in order to align the composition of the latter to approximate that of human breast milk. Much has already been achieved technologically over the years and, indeed, within the past decade, when Teagasc succeeded in developing Alpha-lac, an α-lactalbumin-enriched ingredient that is now commercially used in infant formula. However, there remain some subtle differences that pose an ongoing challenge to researchers in our current programme, which are addressed later in the article.

Overall, traditional IMF manufacturing processes have many in-built safety checks linked to batch-based operations that feature 'traffic light' (go/no) decision-based nodes. Furthermore, IMF is preserved in spray dried powder form for the most part – the dehydration step being the most costly of the unit processes involved. However, traditional processing takes place under relatively dilute concentrate conditions that are substantially prepared from already dehydrated ingredients. Consequently, there is a challenge to identify new technologies that would enable such processes to be undertaken under more concentrated conditions and circumvent unnecessary intermediate processes.

Re-engineering of the infant formula manufacturing process

One research initiative underway is the use of novel shockwave heating and mixing technology to re-engineer existing infant formula manufacturing processes in order to make them more competitive. The result is that a new infant formula process has been designed at Teagasc that is substantially shorter and more energy efficient than existing processes. This process is capable of processing infant formulations at significantly higher total solids (60%) content than is currently practised. The key components of the new process include high shear shockwave steam injection and in-line high shear mixing for batch make-up (recombination of ingredients), thermal treatment and homogenisation. Ingredient interactions dominate virtually all parts of infant formula processing by virtue of the complex nature of the formulations used and the associated processing conditions. For this reason, the research team focuses extensively on the consequences of process changes to the batch make-up step (formulation dynamics) that take into consideration hydration of ingredients, lactose solubility, and colloidal stability of the prepared high solids concentrate as they affect the functionality of the end-product IMF powder.

Process mapping techniques have also been developed to monitor the effects of changing product formulations in order to guide the selection of optimum conditions and ingredient selection. These techniques are currently being used for troubleshooting commercial applications.

Utilisation of MFGM in infant formulation

Research co-ordinated by Dr Phil Kelly investigates opportunities to use components of the milk fat globule membrane (MFGM) of bovine milk as ingredients in infant formula. MFGM is a good source of many glycoproteins and oligosaccharides. Background research undertaken at Teagasc highlights significant potential for the exploitation of biological activity associated with the MFGM layer of milk. The antimicrobial activities that we have observed to date with experimentally produced buttermilk fractions enriched in MFGM tie in with the view that milk is a natural functional food supporting the physiological defence systems of the neonate. MFGM is a source of sialic acid components in the form of glycoproteins and glycolipids, which contribute to anti-adhesion of pathogens. In addition, it also contains xanthine oxidase (an enzyme that has broad substrate specificity and is capable of reducing oxygen to generate the reactive species, nitric oxide and peroxynitrite, by reduction of NO_2) and is, therefore, thought to play an alternative role in antimicrobial defence in the neonatal gut. However, commercially produced infant formula does not possess the antimicrobial activity found within human breast milk. Hence, we believe that much of the antibacterial activity of bovine MFGM is inadvertently destroyed during processing. The opportunity and challenge is to explore options for the recovery of MFGM with biological activity from minimally-processed dairy process streams, characterise the resulting antimicrobial properties against a range of infant pathogens and examine the implications for incorporation of such bioactive ingredients into IMF while adhering to strict compositional and quality guidelines. We believe that successful exploitation of MFGM-rich ingredient sources will represent one more key step in the 'humanisation' of bovine milk as referred to earlier. The strength of knowledge in process technologies has attracted multinational companies, particularly those operating in the area of dairy ingredients and infant formula. Teagasc has responded by extending its knowledge of food formulation and its relevance to infant and other nutritional formulations. Already research outputs from the projects mentioned above are commercialisable as a new approach to manufacturing food/beverage formulations at significantly lower cost.

Teagasc is continuing to maintain a research base in core process technologies, coupled with expanding its scientific capabilities in colloidal and ingredient interaction in order to develop innovative solutions for the infant formula sector in Ireland. In addition, a number of scientifically important bioscience research projects within Teagasc extend the range of competences sought by IMF manufacturers. This evolving axis between chemistry- and bioscience-based research is now key to maintaining Teagasc as a centre of excellence in IMF developments in Ireland. This is also complemented by Teagasc's unique capacity to support IMF NPD needs throughout the whole quality chain, from milk production right through to the final reconstituted powder.

New Teagasc research infrastucture supporting IMF development

New analytical capability for food structure

While nutrient composition and delivery is key to the adaptation and formulation of cows' milk for newborns, processing and preservation techniques impact significantly on quality during its transformation to an end product. Any attempt at diagnosing why an IMF powder does not reconstitute properly during domestic feed preparation demands an understanding of food structure as a diagnostic science with which to fine tune product quality. Powerful microscopic techniques have been applied to visualise system behaviour and ingredient functionality throughout IMF processing. Coupled with the development of new rheology tests, these sophisticated analytical techniques give researchers the capability to simulate industrial processing parameters used during manufacture and track ingredient interactions. Teagasc's National Food Imaging Centre supports a collection of advanced microscopic instruments including cryo-scanning electron, atomic force and confocal laser microscopes.

Development of technologies for production of ingredients for use in infant formula

Teagasc competency led by Dr Mark Fenelon in formulation science and associated processing technologies is centered around the Biofunctional Food Engineering Facility. This has already contributed to the development of strategic research alliances with multinational companies through ongoing collaborative projects. The diversity of separation technologies and supporting expertise is key to Moorepark being able to undertake the pre-commercial scale-up work package in the industry-led, Enterprise Ireland-funded Food for Health Ireland (FHI) project. Ultimately, selected bioactive milk fractions will be the subject of handover protocols from 'mining groups' and taken through various stages of pilot plant scale-up for preparation as biofunctional ingredients under good manufacturing practice conditions for either clinical evaluation or market presentation.

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European Ruminant Infrastructure Network

The European Ruminant Infrastructure Network (ERIN) is an EU support action that examined the present and future needs for ruminant research in Europe, explains BERNADETTE EARLEY.

Towards a European Ruminant Infrastructure Network (ERIN) is an EU support action that aimed to analyse the possible need for a shared European infrastructure dedicated to studies on ruminant physiology. Six partners contributed to the ERIN project: Teagasc; the National Institute for Agricultural Research (INRA) in France; MTT Agri Food Research in Finland; Ludwig-Maximilians-University (LMU) in Germany; the National Research Institute of Animal Production (NRIAP) in Poland; and, Instituto Nacional de Investigacion Y Tecnologia Agraria Y Alimentaria (INIA) in Spain.

The objectives of ERIN were:

- to estimate prospective needs for research on ruminants in relation to future research areas, and in terms of expertise, animals and equipment;
- to assess the future potential of research facilities dedicated to ruminants; and,
- to cross-analyse prospective needs and the supply of facilities with a view to creating an integrated organisation of research facilities likely to match future scientific developments and stimulate synergies in order for European research on farm animals and farming systems to play a leading role.

Research undertaken

ERIN conducted bibliometric analyses from the Web-of-Science, reviewed vision papers and foresight studies, interviewed research managers and members of funding bodies, surveyed research groups and experimental facilities, ran a scenario exercise on possible organisations of the research infrastructure in Europe, and organised a stakeholder conference to discuss the findings of the project and scenarios.

Results

More than 3,000 scientific articles are published each year on ruminant research. In Europe, 400 European institutes or universities carry out research on ruminants. The research groups are small, with half of them having fewer than 10 researchers. The overall collaborations within Europe, and between European groups and partners outside Europe, are extensive; however, collaborations with Eastern European groups remain limited.

Cattle have been and remain the predominant ruminant species studied, followed by sheep and goats, both in terms of number of publications and number of experimental facilities for ruminants. The published articles concern mainly veterinary sciences, agriculture, dairy and animal science, and food science and technology. The information obtained from the research groups and from the experimental facilities contacted in the project (through face-to-face interviews and surveys) confirms the stability of the research areas. However, this apparent stability hides profound recent changes both in terms of research topics investigated and methods of investigation used in research on ruminants. Research on ruminants needs to address new challenges at a global level: food security is an issue of growing importance as the impacts of a rising global population and climate change become clearer, and societal demands to improve the sustainability and the environmental impact of food production force a continued adaptation towards more sustainable systems. Innovative solutions require integrated applications of existing knowledge, science and technology, interdisciplinary networks, and an increased participation of stakeholders, while taking into account societal concerns such as the protection of farm animal welfare.

The five specialised fields that represent the present research interests of research managers and how they may change in the future are: animal nutrition (present 45.7% of respondents; future 54.3% of respondents); dairy science (present 44.3%; future 50%); biology of reproduction (present 38.6%; future 48.6%); molecular biology (present 28.6%; future 58.6%); and, metabolism (present 27.1%; future 37.1%). In addition, the specialised fields representing biotechnology, animal welfare, metabolism, microbiology, herd management, endocrinology, production systems, molecular genetics, and modelling were considered important by 30-40% of research managers and the trends showed an increase compared with present research interests.

The changes that may be made regarding future research objectives in research on ruminants in the next three to ten years, in order of priority, are: increased focus on 'omics' (74.3%); animal health (61.4%); in-depth analysis of biological processes (57.1%); molecular genetics (55.7%); production efficiency (51.4%); environmental impact (51.4%); animal well-being (50%); food quality (47.1%); economically viable agricultural production (45.7%); food safety (44.3%); support for biomedical research (42.9%); advanced imaging tracer techniques (38.6%); genetics and breeding of farm animals (37.1%); economic modelling (32.9%); quality and utilisation of agricultural products (31.4%); metabolic studies (metabolic chambers) (24.3%); and, phenomics

Table 1: The changes that research managers indicated may be made regarding future research objectives in the next three to ten years.

	Percentage			
Topic	**Decrease**	**Remain stable**	**Increase**	**Don't know**
Increased focus on 'omics'	0.0%	10.0%	74.3%	15.7%
Animal health	2.9%	25.7%	61.4%	10.0%
In-depth analysis of biological processes	1.4%	24.3%	57.1%	17.1%
Molecular genetics	4.3%	28.6%	55.7%	11.4%
Production efficiency	4.3%	30.0%	51.4%	14.3%
Environmental impact	4.3%	28.6%	51.4%	15.7%
Animal well-being	2.9%	32.9%	50.0%	14.3%
Food quality	1.4%	34.3%	47.1%	17.1%
Economically viable agricultural production	4.3%	27.1%	45.7%	22.9%
Food safety	1.4%	38.6%	44.3%	15.7%
Support for biomedical research	8.6%	21.4%	42.9%	27.1%
Advanced imaging tracer techniques	2.9%	22.9%	38.6%	35.7%
Genetics and breeding of farm animals	4.3%	34.3%	37.1%	24.3%
Economic modelling	12.9%	30.0%	32.9%	24.3%
Quality and utilisation of agricultural products	10.0%	38.6%	31.4%	20.0%
Metabolic studies (metabolic chambers)	14.3%	31.4%	24.3%	30.0%
Phenomics	7.1%	31.4%	21.4%	40.0%

(21.4%) (**Table 1**). In the past, functional traits that were looked for (e.g., growth rate, milk production) were generally controlled by a few genes and only a few traits in relation to productivity were targeted. Nowadays, more complex traits like fertility or behavioural adaptation need to be better understood. Such traits are often determined by multiple genes, whose expression is largely influenced by the environment. Much larger and more detailed pools of information are required to understand the links between genes, environment and phenotypes, and these will be of interest in the context of the global challenges animal production is facing. This information requires in-depth investigational methods such as metabolomics, transcriptomics and proteomics. In addition, the description of phenotypes will be based on multiple traits to reflect the multiple facets of the adaptation of animals to changing environments. Innovative solutions for farming require taking into account the various environmental contexts of agriculture in Europe, since there will certainly be no unique model of farming but several systems or practices more or less adapted to specific climatic and cultural conditions. Ruminants are now being used more frequently as models for studying human disorders, such as reproductive or developmental disorders. Emerging scientific approaches and tools, including tools developed for biomedical research, are likely to further feed back to agricultural research. Such changes have already started in most places in Europe; however, they are limited by funding possibilities and difficulties in accessing sophisticated investigational techniques.

Conclusions

Close co-ordination between researchers will be crucial to design innovative solutions to help farming cope with global challenges, to increase the efficiency of research, and to make European research more visible within Europe and on the international scene. Experimental facilities will need to develop close links with technological platforms to run in-depth investigations at the 'omics' levels. This will generate large amounts of data that need to be harmonised and shared in common databases. Establishing close links between facilities will allow the construction of such databases as well as biobanks of tissues that could be accessed by researchers. The infrastructure will need to be open in order to stimulate exchanges of ideas, expertise and approaches. It could also allow researchers from countries where experimental facilities are scarce to realise their research objectives. The study found that European research groups are in favour of the organisation of European facilities for ruminants into a shared infrastructure. About 25 research facilities have been identified throughout Europe as suitable to join a European infrastructure (due to their size, quality assurance procedures, equipment, ethical reviewing of research projects, the skills of their personnel, etc.). At present, costs and declining funding are the most common threats found across all research institutions. Ability to attract funding will have a major impact on the capability of research institutions to achieve their objectives. It was indicated that specific expertise and access to equipment and facilities will be required to meet the future needs of researchers. Therefore, the concept of ERIN was considered as timely, relevant and necessary as it would lead to more efficient utilisation of resources and better organisation of ruminant research across Europe. Within an 'infrastructure', the majority of research managers indicated that sharing the cost of research, better management of ethical issues and knowledge transfer would greatly strengthen research collaborations and deliver excellent research. Thus, well-defined scientific objectives, building teamwork, developing and exchanging skills among research and technical staff, communicating knowledge and building effective collaborations, appropriate accountability and well-managed intellectual property, in an ERIN, would greatly facilitate ruminant research in the future.

ERIN held a public conference with the aim of identifying the best scenarios for organising the research infrastructure in Europe to match future needs for research on ruminants. The proceedings are available at: www.erinetwork.eu/erin/conference.

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Milking management of large herds

Researchers at Teagasc's Animal & Grassland Research and Innovation Centre at Moorepark are investigating the implications of herd expansion on milking efficiency, milk quality and overall performance.

Large modern swing-over milking parlour.

Many farmers in Ireland are expanding the size of their dairy herd. The expected abolition of milk quotas by 2015 is likely to speed up this expansion. One challenge when increasing herd size is capturing the potential labour productivity advantages from managing more cows with the same number of people. Milking uses about 33% of time on farms and is a chore where large time savings can be made if the infrastructure and milking routines are optimised. Some Irish farmers managing larger herds are reporting a decline in udder health as evidenced by a higher somatic cell count (SCC) and more clinical mastitis, as well as concerns over the longer time it takes to milk the herd as herd size expands. It is important for herd growth that the most efficient milking methods are established to deliver high standards of milk quality and animal health, and contribute to the goal of more efficient dairy production systems.

Irish research has focused on: establishing the association between herd size, herd expansion and SCC; quantifying the milking performance by focusing on a sample of the largest 5% of herds; and, determining the effect of parlour size and milking routine on efficiency measures in single operator parlours.

Herd expansion and SCC

Performance data from 2,555 milk recording herds for the 2004 to 2008 period were obtained from the Irish Cattle Breeding Federation database and used to quantify the association between herd size, herd expansion and SCC. Only spring calving herds were evaluated. Herds were classified into three equal groups based on average herd size (small = 38 cows; medium = 54 cows; and, large = 79 cows) and three groups based on annual rate of growth (nil = not expanding; slow = increasing at an average rate of three cows/year; and, rapid = increasing at an average rate of eight cows/year). Of the herds in the study, 38% increased cow numbers over the five years and, on average, herd size increased from 48 to 57 cows.

There was a strong association between rate of herd expansion and SCC-derived measures such as average SCC, total cells and proportion of milk recording days where SCC was above a threshold. Herds that were getting larger had a lower SCC than static herds and a lower proportion of milk recording test days where SCC was greater than 150,000 cells/ml. In comparison, there were few associations between herd size and SCC-derived traits. The proportion of test days where SCC was greater than 250,000 cells/ml decreased with increasing herd size. First lactation animals in larger herds had a greater SCC than those in smaller herds, although these differences were relatively small. There was no association between herd size and milk yield. The results of the analysis give confidence that herd expansion does not appear to be a risk factor for SCC. Large herds achieve comparable levels of mastitis control and produce milk of similar or better quality than smaller herds.

There was no association between herd size and milk yield. The results of the analysis give confidence that herd expansion does not appear to be a risk factor for SCC.

On-farm case studies

To understand the practical requirements of milking a larger herd, 20 farms, averaging 270 cows each, were studied. The herds were milked through herringbone parlours that ranged in size from 14 to 44 clusters, considerably larger than the most common parlour size of six units. Milking performance was assessed during two visits (one in peak lactation and one when yields were lower in late lactation) and the farmers completed detailed questionnaires about their mastitis management and milking routine. On visiting, the researchers were able to see first hand the challenges of milking large herds and study the differences in milking management on these farms. It was also an opportunity to listen to farmers' views on how to achieve both labour efficiency and high standards of animal health and milk quality. The throughput of some farms was impressive,

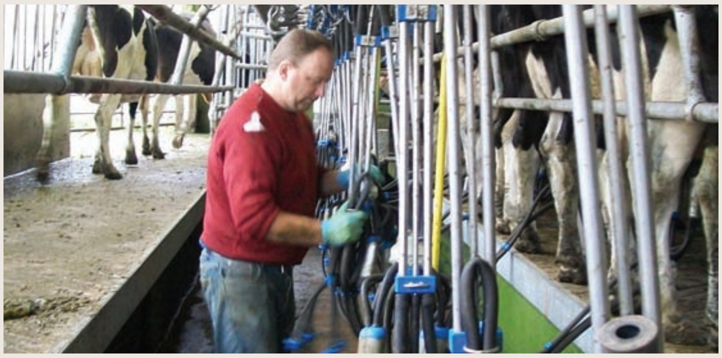
Rotary parlour.

Milking uses about 33% of time on farms.

with rates of 175-200 cows per hour regularly achieved and one example of two operators milking 350 cows in just one hour, while not compromising the quality of mastitis management. The most labour-efficient parlours, if measured in terms of cows milked per operator per hour, were those with 20-25 units and a single operator. The results indicated that, although the number of operators and the number of clusters used were factors in cow throughput, the work routine and parlour procedures were more important than parlour size.

Implications for parlour size

One common question farmers ask is: "How big should my parlour be and how many clusters can one person comfortably handle?" The Moorepark Research Farm parlour, which has 30 clusters and an automatic data recording system, was used to conduct an experiment to provide information with which to guide farmers. Data were collected from 40 milking sessions that differed in the number of clusters that were used (14 to 30) and the routine used to milk the cows (disinfection and preparation of the udder before cluster attachment, or directly attaching the cluster with no pre-milking preparation). As milk yield can differ by at least two-fold during lactation, the experiment was carried out twice, once in early lactation and again in late lactation. The results supported what was observed on farms. If a minimal routine is used, one operator can handle around 20 clusters without automatic cluster removers (fewer in late lactation) without unduly over-milking cows. As parlour size increased, the use of pre-milking preparation decreased milking time per cow but increased row times as well as the proportion of cows that were over-milked, thereby reducing overall efficiency.



Milking management is an important issue for Irish dairy farmers as it affects labour requirements, milk quality and animal health.

Future focus

Milking management is an important issue for Irish dairy farmers as it affects labour requirements, milk quality and animal health. The study has raised a number of questions, including the role of different parlour types for milking larger herds. The project team will complete the evaluation of the large volume of data gathered during the past 12 months and then focus on the question of parlour type and when a farmer should consider milking in a rotary dairy.

This work is being funded by the Teagasc Core Programme.

Dr Jenny Jago is a Senior Scientist at DairyNZ (New Zealand) and conducted this research while on sabbatical at the Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark. **Dr Bernadette O'Brien** is a Senior Research Officer, **Finola McCoy** is a Mastitis Research Officer and **Dr Donagh Berry** is a Principal Research Officer at Teagasc, Animal & Grassland Research and Innovation Centre, Moorepark. E-mail: Jenny.Jago@dairynz.co.nz.

Towards reducing the methane intensity of milk production

Researchers at the Animal & Grassland Research and Innovation Centre in Moorepark, Co Cork, are seeking strategies for dairy farmers to reduce herd methane emissions while maintaining productivity.

Cows undergoing methane measurement at Moorepark, Co Cork.

Enteric methane gas emitted from ruminants during belching and respiration represents the single largest source of greenhouse gas (GHG) from the Irish agricultural sector, not to mention a loss of about 6% of consumed feed energy. Reducing the methane intensity of milk production (emission per kg of milk solids) while maintaining productivity presents a vital challenge because of the conflicting pressures created by industry growth and EU obligations to reduce national GHG emissions.

The Environmental Protection Agency estimates that Ireland's agricultural sector contributed 27.3% of the nation's total GHG emissions for 2008 (**Figure 1**). Using the Intergovernmental Panel on Climate Change methodology it is estimated that 33% of these emissions arise from milk production. Two GHGs – methane and nitrous oxide – mainly arise as a consequence of natural biological processes, while the third – carbon dioxide (CO_2) – is mainly emitted from fossil fuel energy required for milk production. However, methane produced by methanogenic bacteria during digestive fermentation and, to a lesser extent, during slurry storage, is the predominant GHG source. The emission of methane alone is estimated to represent 65.5% of the total GHG cost of milk production. In part this is due to its potent global warming potential, some 21 times greater than CO_2. GHG emissions, expressed as CO_2 equivalents (CO_2eq), amount to approximately 1.13kg per kg of liquid milk and 15.72kg per kg of milk solids produced in Ireland.

As an EU Member State, Ireland is committed to reducing national GHG emissions to a level 20% below those of 1990 by the year 2020. However, since 1990 emissions have increased to 67.44Mt CO_2eq and a 34.9% reduction on the most current (2008) emissions, estimates will now be required to meet the EU target. Adoption of currently available best management practices such as earlier calving, reduced replacement rate, higher stocking rate and longer grazing season provide scope for Irish milk producers to contribute to achieving target reductions in GHGs without necessarily having to reduce the overall output of milk solids. However, milk production in Ireland is forecast to increase with the abolition of EU milk quotas in 2015. In addition, a 2020 production target 50% above 2007-2009 levels is proposed in the recent Department of Agriculture, Fisheries and Food (DAFF) 'Food Harvest 2020' report. This drive for increased milk production, in concert with aims for decreased GHG emissions, poses a significant challenge for the Irish dairy industry. Research designed to reduce the methane emission intensity of milk production has been underway at Teagasc Moorepark, Co. Cork, since 2008, and is funded through the DAFF Research Stimulus Fund. The current project aims to investigate practical mitigation options for Irish dairy farmers to drive industry efficiencies in line with the Teagasc dairy sector Road Map. The road map initiative defines performance improvements in manufacturing milk herds and targets an industry GHG efficiency of 13.53kg CO_2eq/kg milk solids produced by 2018.

Mitigation via diet choice

The enteric methane efficiency of a grass-based milk production system was compared to an indoor high-input total mixed ration (TMR) diet during spring. Two groups of mixed age cows with an average economic breeding index of €105 were offered either a 100% grass diet managed to maximise grazing utilisation or a high quality mixed ration fed to appetite. On average, cows fed TMR ate 28% more dry matter and produced 28% more milk solids; however, they also emitted 37% more methane. This additional gas emission could not be accounted for by their increase in milk production, resulting in a 14% lower efficiency of production than their grass-fed counterparts. The direct enteric methane emission per unit of milk production was 4.22kg CO_2eq/kg of milk solids from cows fed TMR, yet just 3.63kg CO_2eq/kg of milk solids from grazing cows (**Figure 2**). As every litre that TMR-fed cows produced also resulted in a higher methane emission relative to grass-fed cows, the grass

Most enteric methane is emitted during belching and exhalation.

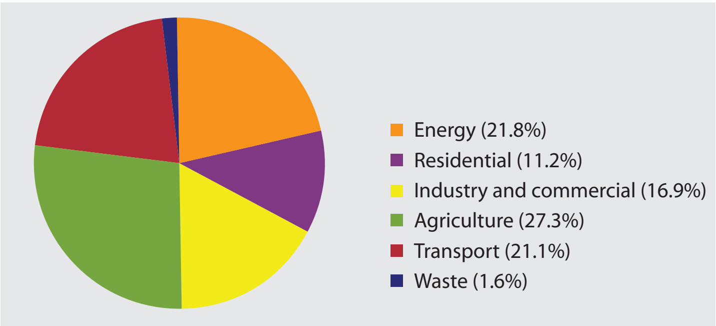


FIGURE 1: Greenhouse gas emissions in 2008 by sector.
Source: EPA National Inventory Report 2010.

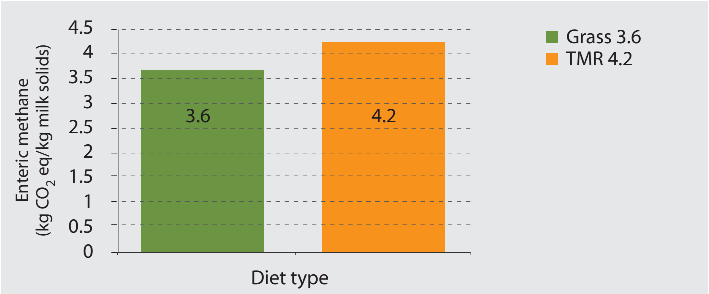


FIGURE 2: Effect of diet upon the enteric methane emission intensity of milk solids production.

system allowed a higher level of milk production relative to its carbon cost to the environment. These results demonstrate that high milk production does not necessarily equate to high environmental efficiency in a climate where grass is a readily available feed for the lactating cow. Irish farmers seeking to improve the GHG efficiency of their milk production system can be expected to achieve this while maximising the utilisation of grass grown and increasing the length of their grazing season. Both strategies will increase the proportion of grass consumed in the annual feed budget while minimising the use of mixed rations during the grazing season.

Potential for mitigation via pasture management

Pasture management decisions, such as grazing rotation length, can improve the quality of pasture available to the grazing dairy herd. Any reduction in the methane emission from grazed pasture arising from an improvement in quality can be exploited immediately to reduce the methane intensity of pasture-based milk production. A direct comparison of the pasture intake, methane emission and milk production of 46 Holstein-Friesian cows grazing perennial ryegrass of contrasting maturity and pre-grazing herbage mass was conducted during the 2009 grazing season. The experimental grass diets differed only by grazing rotation length. The low maturity grass (LMG) was grazed every 14 days, while the high maturity grass (HMG) was grazed on a 24-day rotation. Grass intake was determined via the *n*-alkane technique and, simultaneously, the methane emission of each cow was measured via the sulphur hexafluoride tracer technique. The extended re-growth period significantly increased herbage mass of HMG at grazing: the average herbage accumulated was 1,075 vs. 1,993kg DM/ha for LMG and HMG, respectively. In this study, cows fed LMG produced 9.4% less methane gas than those fed HMG. This resulted in a 13.9% reduction in the methane intensity of milk solids production from the faster grazing rotation. These encouraging results indicate that managing swards to maintain low herbage mass and high leaf:stem ratio may represent a simple yet important tool in optimising the GHG efficiency of milk production, particularly during periods of the grazing season when grass plants exhibit reproductive growth. Further research is now required to assess the robustness of this effect and its potential for transfer to commercial farms.

In a further initiative to reduce the methane intensity of pastoral milk production, a study to compare the relative efficiency of three different breeds is currently underway at the Teagasc Ballydague farm. This study will enable comparison of the methane intensity of milk production from Holstein-Friesian, Jersey and Holstein-Friesian x Jersey cows under three different stocking densities.

The ultimate goal of the research is to develop targeted management strategies that apply currently available resources such as diet, grassland management and cow genotype to optimise the methane intensity of milk solids production from pasture.

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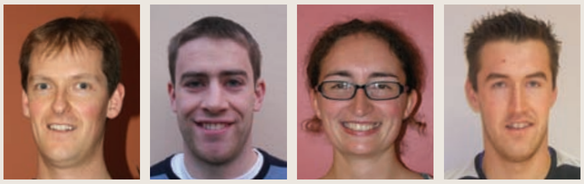

A milk processing sector model for Ireland

Researchers at Teagasc, Moorepark, UCC, UCD and CIT are developing a milk processing sector model to inform business strategies that are fundamental to the development of the industry post quota.

As quota is being removed and the world dairy markets open up there is significant potential for expansion in Ireland. However, the dairy industry will only be sustainable if it can produce high quality dairy products at low cost, thus insulating itself from price volatility. Milk processors that can react to fluctuating markets will achieve higher return for the milk that is produced (Van Der Pool, 2007), ultimately resulting in higher industry returns. A model capable of informing strategic decisions both within and between years could provide valuable information for the dairy industry. As well as being used to develop milk pricing strategies to underpin supply profiles, it can be used to encourage the production of components that will increase milk value. A project to develop such a tool is being undertaken by Teagasc Animal & Grassland Research and Innovation Centre, Moorepark, in partnership with the Teagasc Rural Economy and Development Programme, University College Cork, University College Dublin and Cork Institute of Technology. Consultation is being carried out with processors, the Irish Co-operative Organisation Society, the Department of Agriculture, Fisheries and Food, the Irish Dairy Board and farmer representatives to ensure a complete industry perspective.

Processing sector model

A mass balance model called 'Moorepark Processing Sector Model' (MPSM) that accounts for all inputs, outputs and losses involved in dairy processing has been developed. The model is a mathematical representation of the process of converting milk into dairy products (**Figure 1**). Within the model the production of cheese, butter, whole milk powder (WMP), skim milk powder (SMP), fluid milk and casein is simulated. The key model inputs include the volume and composition of milk intake, product portfolio and composition as well as processing costs. The quantities of products and by-products that can be produced from the available milk pool are calculated. Processing costs are simulated, and the return from raw milk and its individual component values are calculated. The proportion of milk used in the production of each product is defined by the user. The milk then goes through a milk assembly process where the milk is standardised through separation based on final product requirements. Excess cream not used in the production process can be sold off or used in butter manufacture. Excess skim milk remaining from butter manufacture is used in the production of SMP.

Model inputs

In addition to the volume and composition of raw milk and the composition of the products produced, the other model inputs are the product market values and processing costs. The market values used for the dairy products produced in this model are taken from the Deutsch official quotation (www.prodzuivel.nl) and are representative of a three-year average (2008 to 2010). The market price for buttermilk powder (BMP) is assumed to be equivalent to the market price of WMP.

The processing costs are split into two distinctive groups, volume-related costs and product-related costs. The volume-related costs include milk collection and milk standardisation and the volume-related processing costs. The product-related costs include the product-related processing, storage and packaging, distribution and marketing costs per tonne.

Model outputs

The model outputs include the proportion of milk that was separated, total processing costs, volume of products produced and total revenues. Using these outputs the model calculates the milk value in a number of ways: the net milk value, the value per litre and the component values. The net value or return from milk is calculated by multiplying the volume of products produced by their market values less the processing costs. The value per litre is the net milk value divided by the total volume of milk processed. The model values protein and fat per kg and puts a cost on the volume-related processing costs. The component values change as the milk composition, product portfolio and product market values change.

Model application

In order to demonstrate the model, the impact that variation in milk composition has on the volume of products produced, processing costs, product sale value, component values of milk and the net value of milk was examined across three milk types. Milk (1,000L) with three distinct compositions that were representative of: (i) typical Irish Holstein-Friesian (HF) with 3.83% fat and 3.34% protein, (ii) Jersey (J) with 5.33% fat and 4.06% protein, and (iii) the New Zealand (NZ) strain of HF with 4.39% fat and 3.65% protein,was simulated in the model (CSO, 2009; Prendiville *et al*., 2009; McCarthy *et al*., 2006). This analysis was applied to a product portfolio that was representative of the 2008 Irish product mix (FAOSTAT, 2008). In this analysis, 30% of milk received was used to produce butter, 43% to produce cheese, 14% to produce WMP and 13% to produce SMP. Whey and BMP are by-products of this product portfolio.

Results

Greater volumes of dairy products are produced from 1,000L of J milk relative to NZ and HF (**Table 1**). As a result the total processing costs are higher for J milk at €86.4, relative to NZ milk at €81.6 and HF milk at €77.2. As presented in Table 1, J milk generates the highest net milk value of the three breeds at €326, NZ milk generates a net milk vaue of €289 and HF milk generates the lowest net milk vaue at €261. Across the three breeds the component values of milk are similar in that protein is valued higher than fat. The collection and processing (C) value of -0.03 cents per litre is the same across each of the cow breeds. For HF, J and NZ milk a kg of fat is valued at €2.2, €3.4 and €2.1, respectively, with the corresponding values of protein per kg at €6.1, €4.2 and €6.1, respectively. The fat and protein values across the three breeds reflect: (i) the different quantity of products that can be produced; and, (ii) the kg of fat and protein available for processing across breeds from the respective 1,000L.

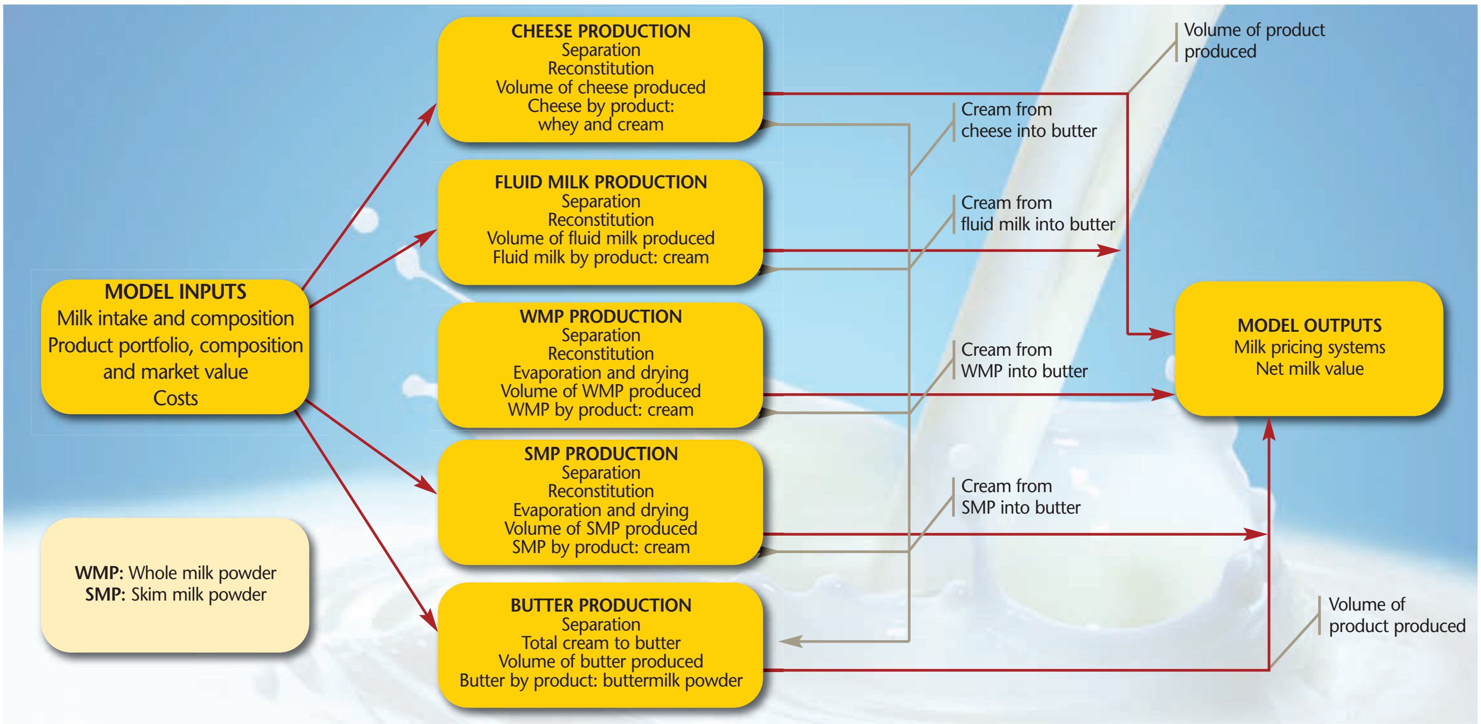

FIGURE 1: Processing model schematic.

Table 1: Volume of products produced, net milk value and component values of milk (2010 market prices).

Volume of products (kg) produced by breed						
Cow breed	Cheese	Butter	WMP[1]	SMP[2]	Whey powder	BMP[3]
Holstein Friesian	46.6	19.6	18.5	33.7	23.4	2.2
Jersey	56.3	30.1	22.2	33.1	25.3	3.7
New Zealand	50.9	22.8	20.2	34.7	25.2	2.7

Net milk value and component values of milk (€) by breed				
Cow breed	Fat (€ per kg)	Protein (€ per kg)	C[4] (€ per L)	Net milk value per 1,000L
Holstein Friesian	2.16	6.14	-0.03	261.46
Jersey	3.40	4.21	-0.03	326.22
New Zealand	2.13	6.06	-0.03	288.62

[1]WMP = Whole milk powder, [2]SMP = Skim milk powder,
[3]BMP = Butter milk powder, [4]C = Collection and processing.

Benefits to industry

As demonstrated above, a processing sector model could be used to aid the decision-making process within the dairy industry. The model would support the implementation of a clear and transparent milk pricing system but would also help to inform business strategies that are fundamental to the industry, e.g., determine the optimal product mix, volume and quality of milk being produced, responding to input price changes and changing product market values. The model presented here works on an annual time step with all inputs remaining constant and is currently being adapted to run on a monthly time step, which will allow seasonal questions to be addressed. This model will then be linked with the Moorepark Dairy Systems Model to estimate the cost and returns to the industry of modifying the milk supply profile. Additional analysis will be run using both models to estimate the cost of mastitis to the Irish dairy industry – farmer and processor alike.

This project is funded by the Department of Agriculture, Fisheries and Food's Research Stimulus Fund under the National Development Plan 2007-2013.

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Benefits of extending the grazing season

The length of the grazing season is now recorded by the National Farm Survey. Researchers in Teagasc's Rural Economy and Development Programme report on the 2009 results.

Producing milk from a low cost grass-based system in our temperate climate is where Irish farmers can excel and gain advantage in the global food market. Extending the grazing season and maximising the amount of time that cows are outdoors on pasture is the recipe for a much-improved farm cost structure, leading to production of milk at a significantly lower cost. Recent studies of the international competitiveness of dairy farming have identified Ireland as being one of Europe's leading low cost producers of milk (Thorne and Fingleton, 2006). Our low-input grass-based system is cited as our main competitive advantage. The recent Department of Agriculture, Fisheries and Food's *Food Harvest 2020* report has set the ambitious target of a 50% increase in milk production by 2020. The 2020 report also stresses the importance of exploiting our 'green' competitive advantage.

In this article, Teagasc researchers summarise their recent research on the economic benefits of extended grazing, which uses new National Farm Survey (NFS) data (Connolly *et al*., 2010) on the length of the grazing season.

Grazing season

For the first time in 2008, the NFS began to record the length of the grazing season on Irish dairy farms. This data, coupled with the existing NFS dairy database, is very useful in that it allows us to assess the economic benefits of extended grazing and its overall relationship with total costs. Farmers participating in the survey were asked when they first turned out their cows to grass by day, full-time and when they were turned back indoors. The grazing season is estimated as the difference between the turned out and turned in dates, with 'out by day' only constituting half a day. The length of the grazing season is then adjusted for calving pattern. Using this method, the average length of grazing season across all dairy farms was 222 days in 2009. According to the distribution of grazing season across the sample in 2009, 25% of farmers had a grazing season of 200 days or less, while at the opposite end of the distribution, 25% of farmers had a grazing season of 230 days or more. As the variation in the grazing season is likely to be affected by farm location factors, i.e., climatic conditions and/or soil type, the link between the regional location of the farm and the grazing season is further analysed. The results of a regression analysis suggest that soil type and region are significant in explaining the variability in the length of the grazing season. Interestingly, when soil type and regional location are controlled for, membership of a dairy farm discussion group is significant and positive, suggesting that other things being equal, membership of a dairy farm discussion group is associated with longer grazing. In other words, members of discussion groups are applying knowledge and technology received through their groups to extend grazing on their farms. It should be noted that there may be a problem of self-selection bias here, as farmers that are members of a discussion group may simply be 'better farmers' than those that are not, and this may explain the longer grazing season, rather than the actual membership. However, this bias is not controlled for in this analysis. **Figure 1** presents the regional distribution of the grazing season. As can be seen, the grazing season in the BMW region is skewed to the left with 40% of farms having a grazing season of 200 days or less, while the data for the south is skewed to the right with 25% of farms having a grazing season of 250 days or more.

Grazing season and costs of production on dairy farms

Production costs on Irish dairy farms are hugely variable. The NFS data from 2009 show that the most efficient one-third of dairy farms produced a litre of milk at a total production cost of 17 cent per litre, while the least efficient one-third of farmers had a total cost of production of 28 cent per litre. Typically, purchased concentrate feeds tend to be the most variable cost items on Irish farms. In 2009, the average quantity of concentrate feed per cow was almost 860kg, with approximately 25% of farmers feeding 1,100kg per cow or more.

It is interesting to consider the relationship between purchased concentrate feeds and grazing season and, in turn, the impact on production costs. The results of a regression analysis suggest that the relationship between concentrate usage per cow and grazing season is negative and linear, and that concentrate usage on NFS dairy farms is typically associated with a decline of 3kg per cow per day of extra

Table 1: Regression results of variable production costs.			
	Variable cost of production (cent per litre)		
Independent variables	Co-efficient of variables	T statistic	P value
Constant	38.08		
Grazing days	-0.175**	-2.32	0.021
Grazing days²	+0.0002	1.77	0.077
Small herds (<40 cows)	1.109**	2.53	0.012
Large herds (>90 cows)	1.141**	1.98	0.049
Yield	-0.00023	-1.28	0.203
R^2	0.20		
F test	14.76*		

n=287

**Significant at the 99% confidence level*

***Significant at the 95% confidence level*

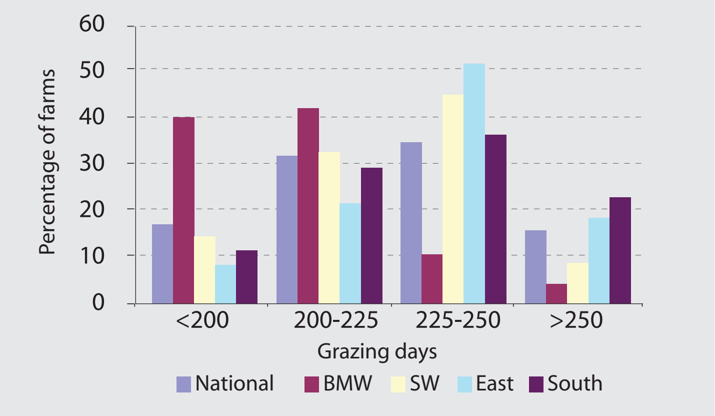

FIGURE 1: Grazing season and regional location: 2009.
BMW region = Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan, Galway, Mayo, Roscommon, Longford, Offaly, Meath, Westmeath and Dublin. Southwest region = Kerry, Clare, Limerick and Tipperary. East region = Kildare, Wicklow, Laois, Carlow, Kilkenny and Wexford. South region = Waterford and Cork.

grazing. While extended grazing is associated with lower concentrate costs, it may also be associated with higher pasture costs, such as use of fertilisers, etc. It is therefore important to consider the relationship between the grazing season and total variable costs of production. **Table 1** presents the results of a regression analysis where variable cost of production is the dependent variable. The independent variables include grazing season, herd size (specified as small herds, mid-sized herds and large herds), and yield per cow.

The Table presents the co-efficient of the independent variables, which measure each variable's relationship with the dependent variable. A negative sign means that an increase in this variable is associated with a decline in variable costs of production, while a positive sign means the reverse. The t-statistics indicate whether the relationship with individual variables is statistically significant, while the F test measures the significance of the overall model. The results of the analysis show that the relationship between variable costs of production and the length of the grazing season is significant and negative, i.e., as the grazing season is extended, the variable costs of production decline. The linearity of this relationship is tested by including the squared term of grazing. This variable is not significant, suggesting that the relationship between grazing and production costs is linear. When the size of the herd and the productivity of the cow are controlled for, the effect of extending the grazing season by one day is a 0.175 cent reduction in the variable costs of producing each litre of milk. Taking a herd of 100 cows with a yield per cow of 4,500 litres, extending the grazing season from 230 days to 244 days, i.e., two weeks, reduces the variable costs of production from 13.3 cent per litre to 12.8 cent per litre or saves the farmer approximately €2,300.

Conclusions

The new data collected by the NFS allows us to chart the length of the grazing season across a large cross-section of dairy farms covering a large geographic spread. Having this data available, in conjunction with all of the other economic information recorded by the NFS, facilitates detailed economic assessments of the returns to extended grazing. The results of the brief analysis presented in this paper suggest that considerable reductions in concentrate use and, by consequence, production costs, can be achieved by extending the grazing season.

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T Events

2010

NOVEMBER

November 17 — *Charleville Park Hotel, Charleville*
November 18 — *Mullingar Park Hotel, Mullingar*

National Dairy Conference – Entering a Decade of Opportunity

The *Food Harvest 2020* Report (FH2020) concludes that "the most compelling picture that emerges of the decade ahead is one of opportunity". Increased global demand for milk and milk products, coupled with the abolition of EU milk quotas in 2015, presents a real opportunity for the Irish dairy sector. Analysis suggests that a 50% increase in milk production is achievable by 2020. But changes are required by all in the dairy industry if this ambitious target is to be met. Change is never easy. Coping with expansion will be difficult – for farmers, for the processing sector and for others involved. Planning and prioritisation is required. By working together and focussing on the benefits of increased milk output, we can make this vision a reality.

What is the outlook for global dairy markets? What are the implications for Irish milk price? Questions are also being asked regarding the timing of expansion and the costs associated with the various options. Expansion is necessary, but it only makes sense to expand from an efficient base. Dairy farming is a tough business; dairy farmers deserve a fair return on their investment and management inputs. The focus must be profitability. Proven technologies must be more widely adopted. Milk price volatility is to be expected; only low cost systems will offer protection.

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November 18 and 19 — *Teagasc Food Research Centre, Ashtown*

International conference on hyperspectral imaging

Hyperspectral imaging is a powerful new tool to collect spatial and spectroscopic data from food and other types of samples. It requires specialist techniques to extract the useful information from the complex images collected. Ireland already has a presence in this field. This conference, the second in the series, aims to bring together experts from many imaging fields from across the globe to share experiences and accelerate applications.

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www.teagasc.ie/ashtown/events/2010/201006-22.asp

DECEMBER

December 2 — *Tullamore Court Hotel*

Jobs in Rural Ireland: How the Rural Development Programme can create & sustain employment

This conference will be of interest to rural development professionals, farmers interested in diversification, the agri-business sector, consultants, advisers and researchers.

www.nrn.ie/the-national-rural-network/events/conference2010/

2011

JANUARY

January 20 — *The Heritage Hotel, Portlaoise*

Outlook – 2011 'Economics of Agriculture'

This major economics conference will explore the challenges and opportunities facing the agriculture sector in 2011 and beyond. An expert panel of speakers will provide their best assessment of the factors that will impact on farm enterprises and profit margins in 2011, with detailed financial analysis presented for each enterprise. This conference will be of interest to farmers and their representative organisations, the agribusiness sector, food processors and suppliers of farm inputs, consultants, advisers and researchers.

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FEBRUARY

February 17 and 18 — *Royal Irish Academy, Dublin*

International Conference: Soils and Society in the Celtic Region

The role of soil science has developed rapidly since the publication of the EU Thematic Strategy on Soils. It is now increasingly recognised that soil science is where agronomy meets environmental science, and therefore, that a strong and vibrant soil science is essential to meet the twin challenges of the new CAP: food security and sustainability. Meeting these challenges requires an in-depth knowledge of the functions that soils perform. The role of science and new research to develop this understanding is paramount. Therefore, the aim of this conference is to identify the actions and research required to turn the debate on "threats to soil quality" into a debate on "soil functions – meeting food security and sustainability". Co-organised by Teagasc, the Macaulay Research Institute (Scotland) and the EU Joint Research Centre (Ispra, Italy), the conference will focus on defining the new research priorities for soil science for FP8 in the Celtic Region, i.e., Ireland, Scotland, Wales, Cornwall, Brittany and Northern Spain.

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MARCH

March 14 and 15 — *Tullamore, Co. Offaly*

Agricultural Research Forum

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

The deadline for receipt of completed summaries is December 6, 2010.

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SEPTEMBER

September 4-8 — *Dublin Castle Conference Centre*

International conference: Eucarpia Forage and Amenity Grasses Section Meeting

The theme of the meeting will be 'Breeding strategies for sustainable forage and turf grass improvement'.

Over the last several decades many developments in science and technology became available for application in breeding. Advances in tissue culture, cross species hybridisation, quantitative genetics and computational power, sensor technology, '-omics'-based sciences and biotechnology all have enormous potential, and are all being used with great success in the breeding of many plant species. We feel that it is appropriate to examine the potential impact of these technologies and sciences on real world forage and turf grass breeding, and ask the question: "What will the future of forage and turf grass breeding look like?" Breeding methodologies and genetic resources will be included in the meeting.

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