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T Research

Research and innovation news at Teagasc

Breeding new potato varieties

New era in bovine genomics
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€50 billion FP7

The start of the Seventh EU Framework Programme (FP) this January provides an opportunity to reflect on the role of the FP to date and look forward to the implementation of the new Programme.

Successive FPs have, since 1984, been the main financial instruments through which the EU supports research and development activities. The Programmes have complemented national research programmes by funding activities with a trans-national or European added value dimension. They have played a critical role in providing an international outlet for Irish researchers and have been an essential source of funding and collaboration, which has contributed to the strengthening of Irish research and the enhancement of its international reputation.

Teagasc has used participation in FPs to: enhance its knowledge and skills base; establish worthwhile international linkages; ensure involvement with relevant leading edge scientific advances; facilitate the transfer of new technology for the benefit of the agri-food industry; and exert influence in the shaping of EU scientific policies and programmes.

Under the current FP (FP6), Irish researchers have drawn down almost €200 million, being particularly successful in the agri-food area, with a draw down of around 2% of the total funding. Teagasc has contributed to this success, notably through securing over €11 million of EU funding for a major project on improving the safety and quality of beef.

With a budget of over €50 billion, FP7 (2007 to 2013) will be of a larger scale and scope than any of its predecessors. Collaborative research will continue to be at the core of the new Programme, with themes that are closely aligned with Ireland's research priorities, including food and agriculture and the life sciences. The Programme also includes new initiatives, in particular the establishment of a European Research Council (ERC), which has been designed to fund excellence in frontier research based on European-wide competition.

The Irish Government has set ambitious targets for drawdown of funds under FP7 and has put in place a new National Support Network to help realise these ambitions. Teagasc will play its part in delivering on the national objective and, in particular, it will seek to build new collaborations in support of its major investment in new bioscience programmes.

Dr Lance O'Brien
Teagasc Head Office

Food

Anti-tumour milk protein 15

α-lactalbumin, a major protein in human milk, has been found to show anti-tumour properties. ANDRÉ BRODKORB describes work at Moorepark, which seeks to confirm if the bovine equivalent causes similar effects when processed on an industrial scale.

Crops

Fuels of the future 28

If the Irish biofuel industry is to develop to a significant scale, and we are to avoid a scenario of replacing mineral fuel imports with biofuel imports, ways of improving the profitability of native production must be found. BERNARD RICE explores our options.

Credits

TResearch
Teagasc | Oak Park | Carlow

TResearch is a Teagasc science publication, produced with the support of AIB Bank, to communicate scientific research to the agriculture and food industry.

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T News

Teagasc foresight study

In October 2006, the Teagasc Authority decided to undertake a technology foresight study of the scientific and technology needs of the Irish agri-food sector and broader rural economy and of the future positioning of Teagasc within it. This decision reflected the challenges posed for the organisation by the rapidly changing environment in which the sector operates and the ambitious targets set by Government in its 'Strategy for Science, Technology and Innovation 2006-2013'.

The study, which will be completed in 2008, will aim to:

- analyse the main national and international drivers of change that will impact on the agri-food sector in the decades ahead;
- identify a vision and devise possible future scenarios for the sector beyond 2020;
- determine strategic technologies and priority areas of R&D for Teagasc, and develop a new R&D strategy; and
- secure the involvement and support of a wide range of stakeholders in the process.

The use of foresight methodologies will enable the mobilisation of broad sets of stakeholders and other interested parties to give collective thought to the long-term needs of the agri-food sector and the science and technology needed to ensure its continued success. The study seeks to create a widespread consensus on how the agri-food sector can contribute to Ireland's new knowledge economy, and will aim to stimulate new thinking and new ideas, and catalyse a process of change across the system. The results will be disseminated principally by way of a major new Teagasc strategy for research and innovation and in a national foresight conference in 2008.

A Steering Committee, comprising national and international representatives from government institutions, industry and universities, will be responsible for guiding the project. The Steering Committee will be assisted in its work by a widely representative Expert Working Group, which will be responsible for the day-to-day running of the project. The Expert Working Group will have the power to establish expert panels in selected areas. The exercise will also be supported by a Foresight Secretariat drawn from within Teagasc and by external foresight expertise.

IRCSET board appointment

Dr Tim Guinee, Teagasc, Moorepark, has been appointed by the Minister for Education and Science to the board of the Irish Research Council for Science, Engineering and Technology (IRCSET). IRCSET was established in June 2001 by the Minister for Education and Science to promote excellence in research across the sciences, engineering and technology, and thereby underpin the knowledge-based economy. Other members of the board are drawn from academic institutes and industries throughout Ireland. The Council's operations are funded by the State through the National Development Plan.

Communicating science

Two new EU publications have been launched to help scientists communicate their research effectively. The European Commission has produced a publication entitled *Communicating Science – A Scientist's Survival Kit,* which gives advice on communicating with the public and the media. The publication can be downloaded from: http://ec.europa.eu/research/science-society/pdf/communicating-science_en.pdf. A hard copy can also be obtained free of charge from the EU bookshop. In addition, as part of a European Commission FP6 project (MESSENGER), new guidelines for scientists on how to communicate most effectively with the media have been produced by the Social Issues Research Centre (SIRC) in partnership with the Amsterdam School of Communications Research (ASCoR). The guidelines can be found at: www.sirc.org/messenger.

Chief Science Adviser

A former Teagasc employee has been appointed to the office of Chief Scientific Adviser to the Government. Professor Patrick Cunningham began his research career with An Foras Taluntais (now Teagasc), becoming Department Head in 1970 and Deputy Director of Research in 1980. Professor Cunningham's work in An Foras Taluntais focused mainly on genetic improvement in the Irish cattle population. He pioneered methods of genetic evaluation, and was responsible for the introduction and assessment of new breeds and strains, and the economic evaluation of breeding options and strategies. The theoretical work that accompanied this research attracted considerable international attention.

In 1964, Professor Cunningham began to contribute to the newly-established Department of Genetics in TCD, and in 1974 he was appointed Professor of Animal Genetics there.

In 1988, he moved to the World Bank as Visiting Professor at the Economic Development Institute. From 1990 to 1993, he served as Director of Animal Production and Health at the Food and Agricultural Organisation (FAO) of the UN in Rome. During this period, he also directed the Screwworm Eradication Programme for North Africa, the largest international campaign of biological control ever undertaken.

Following the BSE crisis in 1996, Professor Cunningham and his colleagues developed a system of DNA traceability for the meat industry, which has been used successfully in Europe for some years. They went on to establish a biotechnology company, IdentiGEN, which deploys these technologies in Europe and the USA. Professor Cunningham is the Chairman of IdentiGEN.

T News

Liam Donnelly receives professorship

Dr Liam Donnelly was recently appointed Adjunct Professor at University College Cork. He will hold this position concurrently with his posts as Director of Food Research, Teagasc, and Head of Moorepark Food Research Centre. The appointment recognises Professor Donnelly's role in building close research linkages between Moorepark and UCC. These linkages will shortly be formalised in the establishment of a partnership between Teagasc and UCC in research on foods for health. The combined strengths of the two organisations will enable the partnership to achieve a leading position internationally in this area of research, which is regarded as a high priority for the future development of the Irish food industry.

Dr Liam Donnelly, Head of Moorepark Food Research Centre, with Dr Peter Kennedy, Vice-President, UCC, on the occasion of his appointment as Adjunct Professor at UCC. (Photo: Tomas Tyner, UCC).

IMS award for AFRC researcher

Jenny Hayes receives her award from Chris Oberst, International Meat Secretariat.

Jenny Hayes, a Research Officer at Ashtown Food Research Centre, has been awarded the 2007 International Meat Secretariat (IMS) prize for Meat Science and Technology. This was in recognition of her work on the development of an accelerated dry-curing process for beef using various physical treatments to promote the diffusion of the cure ingredients. The aim of the work was to develop a modified dry-curing process using a number of novel accelerated curing techniques. These include vacuuming, tumbling and vacuum pulsing, which would increase the relatively slow throughput associated with traditional curing, allowing for more uniform and consistent products.

AFRC awarded largest beef project in Europe

Ashtown Food Research Centre (AFRC) will co-ordinate a prestigious five-year EU Sixth Framework Programme Integrated Project (IP) on beef safety and quality, one of the Centre's main research strengths. The ProSafeBeef project, valued at €17.8m, will start in March and has 42 partners, including universities, research organisations and SMEs from all over Europe, as well as Brazil, New Zealand, Australia, the USA and Canada.

The overall objective of ProSafeBeef is to reduce microbiological and chemical contaminants in beef and beef products and, at the same time, enhance quality, nutrition, choice and diversity in the beef chain in order to boost consumer trust and invigorate the industry.

Declan Troy, Head of AFRC, and Dr Geraldine Duffy, Head of the Food Safety Department, will lead the project. Other researchers at Ashtown will have major roles in the project. Dr Geraldine Duffy will lead research on quantitative risk assessment of microbial and chemical hazards to maximise beef safety. Other researchers will lead work packages in quantitative risk assessment of chemical residues (Dr Martin Danaher), nutritionally enhanced fresh beef (Dr Aidan Moloney, based at Grange), on-farm strategies (Dr Declan Bolton), innovative solutions in packaging of beef products (Dr Paul Allen) and dissemination (Dr Ronan Gormley). Other Irish partners are drawn from UCD and UCC.

2007 Environ

Gaelene Kramers, a Research Officer at Johnstown Castle Environment Research Centre, was awarded the Soil Science Society of Ireland prize for the best presentation at the 2007 Environ Colloquium in Carlow recently. Gaelene's presentation featured her work on preferential flow of slurry through different types of Irish soils using lysimeter and dye studies.

Walsh Fellowship stipend increase

The stipend awarded to Teagasc Walsh Fellows has increased, as of January 1, 2007, from €17,000 to €21,000 per annum. All current Walsh Fellowship students will be eligible for this increase. The stipend is intended to cover the student's university fee and a maintenance grant.

€8.7bn agri-food package

The Minister for Agriculture and Food, Mary Coughlan, TD, recently outlined the measures in the new National Development Plan (2007-2013) that are targeted at the agriculture and food sector. Outlining the agriculture and food package, Minister Coughlan said: "For farmers, this unprecedented investment in Irish agriculture will deliver increases in on-farm investment, enhance our rural environment and secure farmers' income in the long term. For the consumer it will, by way of a strengthened scientific base, underpin quality, nutrition and safety of our food supply chain". She pointed out that these measures address the recommendations of the Agri-Vision 2015 Action Plan and encompass the Rural Development Programme 2007-2013, which awaits EU approval.
The overall package totals €8.7 billion in public expenditure, of which €2.1 billion will be met from the European Agriculture Fund for Rural Development. This compares to total expenditure of €4.7 billion in 2000-2006 – an 85% increase. The measures are spread over four sub-programmes: competitiveness (€1.7bn); environment (€6bn); food industry (€289m); and agri-food research (€641m).

DSS for slurry spreading

Photographed at the AGMET workshop in Johnstown Castle were (from left): Ivor Thysen, DIAS, Denmark; Dr Andrew Moore, CSIRO, Australia; Torben Heisel, farmer, Denmark and Rogier Schulte, Teagasc Johnstown Castle. (Photo: Mary Browne).

Teagasc is developing a prototype decision support system (DSS) for managing slurry spreading. SlurrEinfo is a system that will provide guidance on the timing of slurry spreading to ensure that it is environmentally safe and agronomically optimal. The web-based decision support system has been developed as part of an AGMET (Joint Working Group on Applied Agricultural Meteorology, which includes scientists from most Irish universities and research institutes) project.
"The lifeblood of decision making is useful, timely and accurate information. Computerised DSS for agriculture are used successfully in many countries around the world to provide farmers with vital information to allow them to make the best decisions for their businesses," according to Dr Rogier Schulte, Head of the Agri-Environment Research Department at Teagasc Johnstown Castle.
"DSS services will be of increasing importance in the provision of advisory services to farmers in the future."
A DSS could provide an alternative to the current 'closed periods' for slurry spreading, if it can be successfully developed.
Dr Schulte was speaking at an AGMET workshop to decide on the best ways to provide useful DSS services and how Irish farmers might access them. Most DSS are web-based and accessed via mobile phone, computer or television.
Work is ongoing on improving the system. The next step is to find a suitable web access point for the system and to decide if it should be part of a one-stop-shop for decision support. For example, it could be tied in with liver fluke, fire (particularly important with the increased uptake of farm forestry) and potato blight warning systems.

Tomas Hirschfeld Award

International honours have been bestowed by the International Committee for Near Infrared Spectroscopy on Dr Gerry Downey, Ashtown Food Research Centre, for his work in near infrared (NIR) spectroscopy. The Tomas Hirschfeld Award is presented each year to a scientist of international standing in recognition of their contribution to the field.
Dr Downey has worked at Teagasc for almost 30 years as a food scientist, with specific responsibilities in the dairy and plant food areas. He began research into the application of NIR spectroscopy 20 years ago and was responsible for the introduction of the technique into the Irish grain trade. He continues to be responsible for national monitoring of the technique by grain merchants at harvest time. Over the last 15 years, he has extended his research effort into the use of NIR spectroscopy for qualitative analysis of foodstuffs in general. His PhD thesis was granted for work in the area of food authenticity and quality. In 2005, he was awarded a DSc degree by Queen's University Belfast. He is currently European Editor of both *NIR news* and the *Journal of Near Infrared Spectroscopy,* and is a member of the editorial boards of *Near Infrared Analysis* (published by the Korean Society of Near Infrared Spectroscopy) and *Sciences des Aliments*. From 2001 to 2005, he was Chairman of the International Council of Near Infrared Spectroscopy and now serves as Immediate Past-Chairman. At present, he is Chairman of a project team supported by the International Union of Pure & Applied Chemistry (IUPAC) on global standards for spectroscopic and chemometric data exchange. Dr Downey is author or senior co-author of almost 70 peer-reviewed papers and nine book chapters, and has lectured extensively around the globe on applications of infrared spectroscopy and chemometric data analysis to food quality evaluation. With regard to European R&D projects, he was a member of the management team of the QUEST project (1990-1994), which investigated a range of spectroscopic techniques for food quality measurement, the FAIM project (1994-1997), which dealt with food authenticity issues, and STAFANIR (1996-1998), which was concerned with NIR instrument standardisation. He was also on the management group of the European dissemination project FLAIR-FLOW EUROPE (1999-2003). He is a Work Package Leader and member of the Scientific Committee of TRACE, an integrated project funded under the EU FP6 programme, which commenced on January 1, 2005.

T Feature

Food IQ

Is eating only a necessity or is it more than that? Future trends in functional foods and ingredients could impact on our health and lifestyle, and just how this might happen was discussed at an international forum at Teagasc Moorepark. CATRIONA BOYLE reports.

Research is demonstrating that milk contains numerous bioactive components, which can positively impact on human health over and above its nutritional quality, according to Professor Paul Ross, Alimentary Pharmabiotic Centre (APC) and Head of Biotechnology, Teagasc, Moorepark Food Research Centre. Professor Ross was speaking at the recent forum 'Intelligence in Foods – Exploring a Niche for Ireland'.

For example, milk contains an array of complex carbohydrates with the potential to 'programme' the composition of the gut microflora of the developing infant. In addition, milk fat is known to contain lipid components, such as conjugated linoleic acid (CLA) and butyric acid, which exhibit anti-tumorigenic and/or immunomodulatory properties.

"Perhaps the most exciting potential health-promoting properties of milk lie in the actual amino acid sequences that make up its major casein and whey protein components. Such sequences can be released and made bioavailable through proteolysis by digestive enzymes, or through the action of gut bacteria.

"These released peptides have been shown to exhibit a range of properties, including antimicrobial, anti-hypertensive and immuno-stimulation, and may even affect mood and satiety. Systematic mining of milk for these 'latent' health components has enormous potential to form the basis of new ranges of functional foods for the Irish industry."

Professor Ross will occupy the position of incoming Director of the 'Food and Health Research Partnership' with UCC. The partnership plans to investigate the potential health benefits of components of a wide diversity of foods, leading to the development of new ranges of functional foods with scientifically validated health claims.

Food and mood

Professor Ted Dinan described the relationship between food and mood. Professor Dinan is a Principal Investigator in the APC and Professor of Psychiatry at University College Cork.

Professor Dinan explained that the regulation of mood is complex and, at this point in time, only partially understood. "It is clear that significant psychosocial stress is frequently an important factor in the genesis of depression. Genetic vulnerability to depression can also be of relevance.

"Serotonin is a neurotransmitter that plays a key role in regulating our response to stress, and it has been shown to be abnormal in patients suffering from depression. Levels of serotonin in the brain are dependent on a dietary intake of tryptophan. The daily intake of this amino acid in our diet is important in the regulation of mood.

"Likewise, diet can play a role in regulating the hypothalamic-pituitary-adrenal axis, which is the central hormonal system regulating the stress response. Our data indicate that certain probiotics can reduce the activation of this system and may have a role to play in treating depression.

"It may be possible to produce functional foods that augment current therapies or provide an alternative and more acceptable therapeutic approach. Depression is a major market with considerable unmet need in terms of functional foods."

"By working together, the research community in Ireland can succeed in realising the significant market opportunities available in the functional foods sector."

Minister for Agriculture and Food, Mary Coughlan, TD.

Health claims for functional foods

Health claims provide a means of effective communication of the health benefits of functional foods to consumers and are key drivers of growth in

this food sector, explained Professor Albert Flynn, Department of Food and Nutritional Sciences, UCC. Professor Flynn is Chairman of the European Food Safety Authority (EFSA) Scientific Panel on Dietetic Products, Nutrition and Allergies. He is also Chairman of the Scientific Committee of the Food Safety Authority of Ireland.

"Consumers need simple clear information on health benefit and independent proof of efficacy. Regulation is needed to facilitate substantiation of claims, protect the consumer, and to promote and protect innovation in industry," said Professor Flynn.

"A common strategy between industry and public institutions is beginning to emerge. Teagasc is giving a high priority to this research area and is currently making major new investments in programmes, staff and facilities."

Dr Liam Donnelly, Director of Food Research at Teagasc.

Such regulation is evolving in a number of regions globally, e.g., North America, Japan and other Asian countries, Australia and New Zealand. A new EU Regulation on Nutrition and Health Claims was adopted in 2006, and came into force in January 2007, which provides a regulatory framework for EU-wide health claims. This includes disease risk reduction claims, which are particularly relevant for functional foods. Such claims will need to be supported by scientific evidence demonstrating the specific physiological effect(s) and/or the role of a product in reducing the risk of disease, and the appropriate intake required to obtain the effect. These claims will only be approved by the EC following an independent evaluation by the European Food Safety Authority (EFSA) of scientific substantiation of health claims. Several conditions will govern the use of these claims. Claims related to health should only be made for a food as part of a total dietary pattern and must apply to the amount of food normally consumed.

In addition, a claim must be understandable to the average consumer and should not imply that the product can cure, treat or prevent a disease (i.e., not a medicinal claim). Not all foods will be allowed to carry health claims. For example, claims will not be permitted on alcoholic beverages and will be restricted to foods with appropriate nutrient profiles. These profiles will be established by the EC with the advice of the EFSA.

"This is to ensure that health claims promote nutrition policy goals and are of help to the consumer in choosing a healthy diet. Functional foods are science-driven and the regulation of health claims for functional foods in the EU will provide a major stimulus for investment in nutrition research and innovation in the food sector," explained Professor Flynn.

FFNet

Dr Ronan Gormley, Teagasc Ashtown Food Research Centre, told delegates about the EU FunctionalFoodNet project, which was set up to help 160 companies in 20 countries (especially small-to-medium-sized enterprises) to exploit opportunities in functional foods via workshops, company networks and the project website (www.functionalfoodnet.eu). The network is a specific support action of the EU 6th Framework Programme and, so far, 15 Irish companies have joined.

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T Feature

Harnessing the power of IP

MIRIAM WALSH explains why research organisations must recognise the importance of intellectual property.

In recognition of the importance of sustaining economic growth and enhancing national knowledge-based competitiveness, emphasis on science and technology (S&T) policies has grown internationally. Ireland's entry to the arena is recent. While EU membership has had a significant influence on government policy, particularly by imposing the discipline of evaluation, it was not until 1996 that S&T policy received a major boost with the publication of the first government 'White Paper on Science, Technology and Innovation' (STI). Further progress was made with the setting up of Forfás, an industrial policy advisory board responsible for STI policy, and the Interdepartmental Committee on Science, Technology and Innovation (ICSTI) in 1997.

Knowledge driver

Research, as a key source of knowledge and new ideas, is viewed by the Government as central to success in the generation of this new 'knowledge' economy. A main objective has been to stimulate a self-sustaining capacity for innovation, increase the gross expenditure on research and development (GERD) and stimulate industrial R&D functions.

R&D expenditure in business, higher education and public research has increased threefold in the past decade, influenced by the National Development Plan (NDP) 2000-2006, which includes a major research, technology development and innovation (RTDI) component of €2.5 billion.

Based on the 2004 EU R&D Action Plan, an Irish Action Plan for R&D to 2010, prepared by Forfás ('Building Ireland's Knowledge Economy – The Irish Action Plan for Promoting Investment in R&D to 2010') advances a vision of Ireland as "being internationally renowned for excellence in research within an innovation driven culture". This vision is based on targets, including a significant increase in expenditure in R&D, and the doubling of research employees. Although there is still some way to go, the NDP has contributed significantly to the increased performance, efficiency and productivity of research in the public sector. The planned increase in investment in science as outlined in the 'Strategy for Science, Technology and Innovation 2006-2013' is further evidence of the Irish Government's long-term commitment.

Ireland's innovation performance

As a result of recent investment, Ireland's overall innovation performance, based on the European Innovation Scoreboard (EIS), resulted in an 11th place ranking out of 25 EU member states in 2005. While we score above average on some indicators, such as high tech export share and supply of new science and engineering graduates, our patenting activity is particularly low, ranking us well below the European and Organisation for Economic Co-operation and Development (OECD) averages in terms of European and US patent applications and patents granted. The level of patenting activity is used as an approximate measure of innovation output. A low level of awareness of intellectual property (IP) had been identified as a significant barrier, especially in public research organisations (PROs).

The Government has recently acknowledged the importance of IP management issues, such as successful technology transfer and research commercialisation, in ensuring significant social and economic benefits as a result of publicly funded research. ICSTI prepared two National Codes of Practice in relation to the management of IP in PROs to deal with the lack of clarity and guidelines in this area. This has been followed up by a commitment to provide over €30 million over five years to strengthen the technology transfer functions in PROs.

Ireland's IP policy

Current policy in Ireland supports a two-pronged approach, which involves strengthening the IP/commercialisation functions within public research and higher education institutes, and developing a range of measures to promote

and support collaborative links with industry. The 'National Code of Practice for Managing Intellectual Property from Publicly Funded Research' (ICSTI, 2004) aims to assist in the professional management of IP generated by the public research system through harmonisation of IP management systems across PROs and improving systems to support the identification and exploitation of Ireland's IP. Traditionally, industry has had a negative view of the process of IP licensing from universities/research institutions. Problems are frequently encountered in negotiating collaborative research agreements, with potential conflict relating to ownership of results, fair share of returns and culture clashes. The 'National Code of Practice for Managing and Commercialising Intellectual Property from Public-Private Collaborative Research' (ICSTI, 2005) aims to assist PROs with negotiations and enable prospective collaborators to approach new collaborations with a common understanding of the IP issues involved. Such measures should help Ireland to benefit fully from the significant levels of investment in R&D in recent years, by supporting the transfer of the knowledge generated to industry.

IP management in Teagasc

As outlined in the 'Statement of Strategy 2005-2007', Teagasc's mission is "to generate and apply new knowledge for the sustainable development of agriculture and the food processing industry to enable it to respond profitably to consumer demands and requirements". To underpin the long-term S&T needs of the agri-food industry, the organisation is investing heavily in new biosciences programmes. This will contribute to attaining the vision outlined in the report of the Agri-Vision 2015 Committee (Department of Agriculture and Food, 2004).

In national S&T policy, investment in public research is a high priority and the level of investment is very substantial and likely to grow further. Also, as our food industry, in particular, aims to move from the production of basic commodities to more differentiated products with higher added value, and to be more consumer-driven, close links with industry and research commercialisation will become increasingly relevant. In line with the national vision for the creation of an innovation driven culture, the professional management of Teagasc IP is being facilitated through significant investment in a dedicated technology transfer function and support services for its researchers and collaborators.

According to the 'National Code of Practice for Managing Intellectual Property from Publicly Funded Research' (ICSTI, 2004): "Transparent and consistent procedures for managing IP are key to transferring the knowledge generated in our PROs to industry and therefore to commercial reality". The Teagasc 'Policy and Procedures on Intellectual Property' (IP policy) aims to set guidelines and to provide an equitable and consistent framework within which Teagasc IP is developed and managed for the benefit of the organisation, the inventors and the public good. The IP policy endeavours to encourage and promote the development of IP that is of value to the organisation and its collaborators, in order to optimise socio-economic benefits. It also aims to ensure an equitable return to those involved in research that is successfully commercialised, and to encourage further participation in such activities through appropriate financial rewards accorded to the inventor(s) and collaborators.

An important aspect of the policy is patenting. Although a granted patent does not guarantee commercial success of a product/process, it adds value to the invention and therefore adds to the bargaining power when approaching parties interested in licensing the invention. Our policy supports an increase in the number of patent applications for inventions with real commercial potential, and the more active pursuit of potential licensees who could use this technology for the public good, while still ensuring that certain information is made freely available for dissemination.

IP successes

Teagasc's existing IP portfolio incorporates plant variety rights and patents on novel compounds, uses and processes such as probiotic bacteria, bacteriocins and processes for manufacturing cheese. The majority of the IP generated is food related. Increased patenting and licensing activity within Teagasc and jointly with collaborators in a range of areas, including animal and crop science, nutraceuticals and functional foods, should reflect an increased awareness of industrial needs and the commercial value of research outputs of Teagasc and an increased level of uptake and exploitation of its IP. A higher degree of direct collaborations with industry, closer monitoring of research outputs and increased awareness of IP issues should facilitate such developments.

Research, as a key source of knowledge and new ideas, is viewed by the Government as central to success in the generation of this new 'knowledge' economy.

Given the organisation's plans for increased investment in centres of excellence, a significant increase in more complex interactions between multiple partners is envisaged, and the need for trust and flexibility when managing such interactions is recognised. It is important that such direct collaborations remain compatible with our public mission, and the guidelines contained in the National Codes of Practice for IP mentioned above serve to do this.

Conscious of its research public service role and the increasing importance of competitiveness and innovativeness within the Irish agri-food sector, Teagasc seeks to achieve a balance between free dissemination of knowledge and legal protection and exploitation of its research results.

Miriam Walsh is Teagasc's Intellectual Property Officer, based at Teagasc Head Office, Oak Park. Her role in Teagasc is to co-ordinate a centralised technology transfer function to support research programmes, to educate and train researchers to recognise and protect useful IP, and to support the protection and commercialisation of novel IP generated by Teagasc researchers, for the benefit of Teagasc, the inventors and the Irish economy.

Nitrates calculator

Researchers from Johnstown Castle Research Centre have been working with specialists in Teagasc's advisory service to help Irish farmers comply with the Nitrates Directive. STAN LALOR and MARK GIBSON explain.

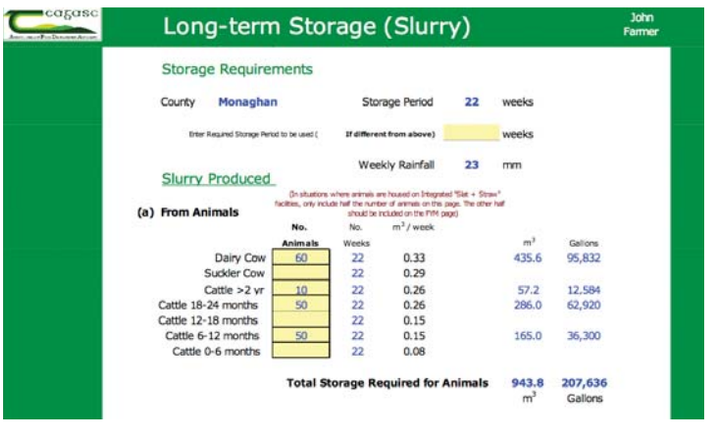
The European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 were signed into law on July 18, 2006. These regulations require that all farmers operate within a host of legally defined criteria. In particular, stocking rates, fertiliser usage and farm 'waste' storage facilities must now meet the requirements of the regulations, and compliance is also linked to the Single Farm Payment Scheme (known as cross compliance).

Clients receive an easy-to-read report that contains fertiliser recommendations and full details of the farmyard assessment.

Assessing and calculating the requirements of the regulations on a farm-by-farm basis can be a complicated process. In order to help advisors and farmers to assess their situation and plan for necessary amendments to their system, a user-friendly tool for performing the calculations required has been developed by Teagasc in Johnstown Castle in conjunction with environment specialists in Athenry. By entering information on livestock numbers, land area, soil test results, and details of farmyard structure and management, the 'Nitrates Action Plan Whole Farm Calculator' will automatically perform the calculations regarding stocking rate, slurry and soiled water storage, and fertiliser recommendations for the individual farm (see **Figure 1**).

Nitrates calculator

Table 1 shows the input required and the output produced by the calculator. Contained within the calculator are all the background details relating to stocking rate, slurry storage zones, storage requirements and fertiliser application rates.



Long-term Storage (Slurry)

John Farmer

Storage Requirements

County Monaghan — Storage Period 22 weeks

Enter Required Storage Period to be used (— If different from above) ____ weeks

Weekly Rainfall 23 mm

Slurry Produced

(In situations where animals are housed on Integrated "Slat + Straw" facilities, only include half the number of animals on this page. The other half should be included on the FYM page)

(a) From Animals

Animals	No.	Weeks	m^3 / week	m^3	Gallons
Dairy Cow	60	22	0.33	435.6	95,832
Suckler Cow		22	0.29		
Cattle >2 yr	10	22	0.26	57.2	12,584
Cattle 18-24 months	50	22	0.26	286.0	62,920
Cattle 12-18 months		22	0.15		
Cattle 6-12 months	50	22	0.15	165.0	36,300
Cattle 0-6 months		22	0.08		
Total Storage Required for Animals				943.8 m^3	207,636 Gallons

FIGURE 1: Example showing part of the "Slurry Storage" sheet. Slurry production is calculated automatically from the livestock numbers entered.

Teagasc advisors can now quickly assess a farm for nitrates compliance.

TABLE 1: Summary of information required and output produced by the calculator.

Worksheet	Input required	Calculated output
Client details	General information on client, including year and county	–
Stock numbers and land	Average livestock numbers Organic manure imports/exports Land area farmed	Stocking rate on grassland and whole farm Extra land or stock reduction required to comply with limits
Soiled water (short-term storage)	Areas of yards producing soiled water Milking cow numbers and parlour management Soiled water storage tank dimensions	Soiled water storage available Soiled water storage required
Farmyard manure (FYM)	Numbers of animals housed on straw Dimensions of straw-bedded sheds and FYM stores	FYM production (and storage required) FYM storage available Straw requirement Seepage production
Slurry storage (long-term)	Numbers of animals producing slurry Slurry storage tank dimensions Areas of open yards producing slurry	Slurry storage required Slurry storage available
Fertiliser (tillage)	Details of each field: crop, area, organic manure usage, soil test results	Chemical fertiliser that can be applied to each crop
Fertiliser (grassland)	Concentrate feed usage Details of each field: soil test results, organic manure usage	Chemical fertiliser that can be applied to each field
Report	None: generated automatically	Summary of all information entered and calculated

The calculator is designed to allow advisors or farmers to rapidly assess an individual farm for soiled water, farmyard manure and slurry storage requirements. The calculator will also determine the maximum chemical nitrogen and phosphorous fertiliser allowances for the farm.
By performing the calculations automatically from the information entered, the advisor and farmer can easily and reliably assess the situation and make plans, without having to wade through the individual calculations and scenarios each time. Clients receive an easy-to-read report that contains fertiliser recommendations and full details of the farmyard assessment.

Stan Lalor is a Research Officer working on nitrogen utilisation from organic manures at Johnstown Castle Environment Research Centre, Wexford.
Mark Gibson is an Environment Specialist working in the area of nitrates, REPS and cross compliance at Teagasc Athenry.

Old ground and new horizons: developing our soil resources

Water and air quality have received much attention in recent years. With the forthcoming Soils Framework Directive, soils are likely to become a major focus. KAREN DALY, RÉAMONN FEALY and DEIRDRE FAY describe ongoing work to develop a comprehensive soil map for Ireland.

Educating a new generation of soil scientists in some practical lessons in soil. (Picture courtesy of Soil-net.com.)

Soil is the fertile skin of the earth. It is our life support system, crucial for the production of food and critical for the productive economies of the world. Soil also sustains life and plays a central role in determining the quality of our environment. Knowledge of our soils would seem to be an obvious prerequisite for maintaining a sustainable agro-environmental economy, yet there are many areas with uncharacterised soils in our detailed national soil survey.

Developments at national and European level have highlighted the importance of soils, and a recently adopted Thematic Strategy for Soil Protection by the European Commission has identified soil protection as the basis of the forthcoming Soils Framework Directive (SFD). As a member state, Ireland will be obliged to report to the European Commission on the threats to Irish soils, using soil maps as the fundamental reporting tool.

At home, the Single Farm Payment (SFP) lists soil protection as a requirement to maintain lands in good condition, which necessitates an understanding of soils on the farm. These tasks will pose a stern challenge to both land users and policy makers. Research scientists at Teagasc Johnstown Castle and Kinsealy are collaborating on a methodology to build a comprehensive soil map and soil information system, which will provide a valuable national resource for soil users and policy makers, and fulfil our reporting requirements at European level.

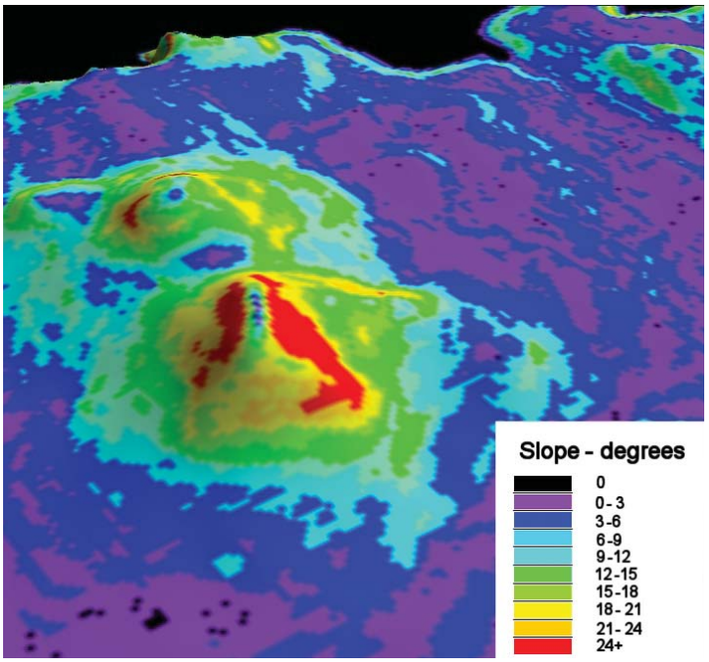
Knowledge of our soils

Soil is an organic natural body in constant interaction with its environment, forming a mosaic of different soil types across the landscape. Soil survey and soil mapping provide us with the tools to visualise this by mapping the location and distribution of these soil types.

There is now a requirement to harmonise soil data across Europe in response to an emerging soil strategy that will include a Soil Framework Directive and monitoring network.

Classifying and describing soils provides us with the basic knowledge from which interpretations of soil functions and applications can be made. For example, soil suitability for grassland and cultivation is a widely used interpretation of soil survey that links the physical and economic features of soils. The 1972 publication, *The Potential of Irish Land for Livestock Production*, by Lee and Diamond, is one of a number of landmark publications that draws on an interpretation of soil survey and knowledge

Ground-truthing: methods for mapping our soils must include traditional soil profile descriptions such as here at Kilmallock, Limerick.



Belderg slope model. Belderg, North County Mayo: colour-coded slope map 'draped' over corresponding elevation model. One example of physiographic landscape features that can be used in predictive soil mapping.

of Irish soils. Other examples include reports on the resource and potential of Irish soils for forestry production and utilisation of peatlands. Apart from the production of food, fibre and fuel, soil has many other functions and services, such as the provision of habitat, nutrient cycling and contaminant transformation, water cycling and climate regulation, to name but a few. Reports from the European Commission indicate that many of these functions are under threat, and soil protection is now placed on the same level as that of water and air. The European Commission has identified eight threats to soil: erosion; loss of organic matter; compaction; salinisation; landslides and flooding; sealing; loss of biodiversity; and contamination.

A soil strategy in the form of the forthcoming SFD is about both soil protection and the sustainable use of soils, in a way that preserves the economic, environmental and social functions of soils, which are essential for human life. It is against this backdrop that the concept of soil quality has originated.

Under the SFP, the Department of Agriculture and Food has published a 'Guide to Cross Compliance', setting a requirement that all agricultural land is maintained in good agricultural and environmental condition with special reference to soil protection and quality; specifically, erosion, organic matter and structure. These aspects of soil quality require knowledge of the nature of soils on the farm, a knowledge that many farmers and advisors have traditionally relied upon to match the stock-carrying capacity of land and the sustainability of farming systems to soil type, based on soil survey and local knowledge of soils.

Reports from the European Commission indicate that many soil functions are under threat, and soil protection is now placed on the same level as that of water and air.

Soil information in Ireland

An inventory of soil information in Ireland has found that mapped data on the distribution of soil types in this country is variable and incomplete.

The National Soil Survey, established in 1959, surveyed Irish soils in detail on a county-by-county basis, completing 44% of the country. The basic unit of soil classification in the detailed survey is known as the 'soil series'. This is the carrier of information on the nature and properties of a

soil, which enables us to describe its functions and applications. Each soil series is provided with a description of the soil profile, which includes its location on the landscape, the colour and texture of each horizon, the extent to which it occupies the soils of the county and, importantly, its suitability for grazing, tillage and other farming systems. This information is further supplemented by analytical data describing the chemical and physical characteristics of each soil horizon. To date, approximately 300 Irish soil series have been identified and characterised within the surveyed counties.

While ordering and classifying objects in the natural environment is a common scientific activity, classification of soils is more complex than for plants and animals. Observable properties such as structure and colour change gradually with distance, over the landscape, making soil a continuum and not a discrete body. Thus, soils develop as a result of soil-forming factors, such as parent material, climate, time, topography and living organism, and this has become the basis for classifying soils and understanding their genesis since the 19th century. At soil series level, the unsurveyed counties of Ireland leave a gaping hole in our knowledge of Irish soils.

Researchers at Teagasc Johnstown Castle and Kinsealy are proposing a methodology to develop a comprehensive national soil map using existing data from the detailed county maps in conjunction with predictive soil mapping techniques for the remaining unsurveyed areas of the country.

New challenges for Irish soil scientists

There is now a requirement to harmonise soil data across Europe in response to an emerging soil strategy that will include an SFD and monitoring network. Under the SFD, Ireland will be required to report to the European Commission using a complete national soil map at 1:250,000, with an international soil classification system, known as the World Reference Base for Soil Resources (WRB).

Researchers at Teagasc Johnstown Castle and Kinsealy are proposing a methodology to develop a comprehensive national soil map, using existing data from the detailed county maps, in conjunction with predictive soil mapping techniques for the remaining unsurveyed areas (56%) of the country.

Completing this map will bring a number of challenges to Irish soil scientists, namely, developing new expertise in soil mapping and classification, while drawing on the expertise of the original soil surveyors to provide guidance with existing surveyed areas. The proposal will explore methods such as rationalisation of soil series, amalgamation of soil series into larger mapping units known as soil associations, and a correlation of national soil series classifications into WRB, which will require a significant input of resources, funding and training.

In the unsurveyed areas of the country, predictive mapping tools that can extrapolate soil associations based on physiographic and topographic criteria will be explored. This technique seeks relationships between environmental variables and soil properties, which are used to develop a model that can be applied within a geographic information system to create a predictive map. Predictive soil mapping methods vary from simple statistical models to more complex techniques and expert systems. For unsurveyed areas of Ireland, finding the appropriate predictive mapping tool and validating the output with field survey will demand a commitment to resources and funding, with research-oriented projects in this area that provide a skill base for the soil science community and add significantly to our national soil resources.

Finally, the specification for a soil information system for the storage and distribution of existing and future soil data in Ireland will also be developed during the project. As part of this process, a workshop held at Teagasc Johnstown Castle in November 2006 invited national and international experts to share their experience and expertise in this area, and a final report and proposal is due for publication in 2007.

In addition to building on our knowledge of soils, there is a pressing need to rebuild our educational resources to support the training of scientists in soil information and soil functions. An example of advances in this direction is Soil-Net.com, a free environmental educational resource about soil, aimed at school ages 5 to 16 in the UK. Soil-Net offers a broad coverage of soils information: introducing soils; examining the global cycles; presenting the functions soils perform; looking at the diversity of world soils; and considering the threats and concerns facing soil resources.

As a fundamental national resource that maintains a productive society, soil is possibly the most complex natural medium; we need to think strategically about investing in developing our knowledge of it and realising its potential.

Acknowledgements

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Anti-tumour milk protein

α-lactalbumin, a major protein in human milk, has been found to show anti-tumour properties. ANDRÉ BRODKORB describes work at Moorepark, which seeks to confirm if the bovine equivalent causes similar effects when processed on an industrial scale.

Human milk is the ideal, custom-made food for newborns and infants because it provides all the required nutrients in correctly balanced proportions. If a mother is unable to, or chooses not to breastfeed, then infant formula is the most adequate substitute during the early stages of life. Over the last 50 years, considerable research has been devoted to improving the protein quality of infant formula. Changing the casein/whey protein ratio improves the protein profile in the formula. However, the proportion of specific whey protein still differs dramatically from that of human milk. In human milk, α-lactalbumin (α-la) is the dominant protein, whereas in bovine whey, it is β-lactoglobulin (β-lg). β-lg is not expressed by the human mammary gland and, therefore, is not found in human milk. This has led to a drive to 'humanise' or 'adapt' the formulation to adjust for the different whey protein and amino acid profiles of human and bovine milk. Bovine α-la, with its high homology to human α-la, is an ideal protein to overcome this discrepancy. α-la-enriched whey protein fractions with a reduced β-lg content are therefore of high interest to manufacturers of infant formula.

α-la-enriched whey protein concentrates can be produced commercially using technologies developed at the Moorepark Food Research Centre, and these can be utilised as an ingredient in infant formula. Moorepark has now launched a new project that explores further health claims of α-la that go beyond the nutritional benefit at the amino acids level.

α-la as anti-tumour agent

In addition to the nutritional benefits of α-la, it was recently reported that modification of human α-la can cause apoptosis in tumour cells, i.e., it can destroy tumour cells by programmed cell death. Swedish researchers have already carried out successful clinical trials on the compound, which was dubbed HAMLET, an acronym for Human Alpha-Lactalbumin Made Lethal to Tumour Cells.

A particular protein variant of α-la was found to have the lethal effect. It consists of a calcium-depleted apo form of α-la in a so-called molten globule state, i.e., partially unfolded, which is stabilised, or 'kinetically trapped', by a fatty acid cofactor. It is noteworthy that the α-la/fatty acid interaction is stereo-specific, i.e., only unsaturated cis fatty acids bind to α-la and only the C18:1:9cis fatty acid (oleic acid), bound to α-la in a compact conformation, is active against tumour cells. These newly described human

α-lactalbumin, a major protein in human and bovine milk, can form a complex with oleic acid, a major fatty acid in milk, resulting in a new compound with added biological function.

α-la compounds, in their isolated forms, are currently being developed as potential candidates for therapeutic or prophylactic treatment of cancer. The objective of the Moorepark project is to establish whether similar biological effects may be achieved using cow's milk products, i.e., to form the bovine equivalent – BAMLET. The project is being carried out in collaboration with Dr Nora O'Brien of University College Cork, a specialist in the field of apoptosis in cell culture model systems. The findings of the project could have significant implications for the production of bovine α-la or whey protein products that contain α-la, as it is desirable to retain any potential biological function of the protein. Based on information obtained so far, the manner with which α-la is processed may be a major factor in determining whether these new and exciting biological activities are maintained or lost. To date, the potential health benefits of the BAMLET dairy products for human consumption (in particular for newborns and infants) are unclear, and whether or not such a complex is formed at any stage during digestion remains highly speculative. Therefore, it is necessary to study this newly discovered biological activity of α-la from a food ingredient perspective. Hence, the new research project is being planned to address these key questions.

Acknowledgement

This work is supported by Seed Funding of the Dairy Research Trust.

Dr André Brodkorb is a Research Officer working in physical protein chemistry in the Moorepark Food Research Centre, specialising in the structure/function relationship of dairy proteins.

FOODCOMM

DR MAEVE HENCHION and CLAIRE McGEE describe a beef and pigmeat supply chain study at Ashtown Food Research Centre.

European food markets are changing. New developments – including reduced market support for agricultural and food products following Common Agricultural Policy (CAP) reform, globalisation, retail concentration and competition, new consumer trends, and stricter environmental and food safety regulations – present challenges and opportunities for all food businesses, from farmers to retailers. The development of measures to address these challenges, exploit new opportunities in the European food sector and promote sustainable development of competitive food chains requires research. This research need has been identified by industry sectors across Europe, and is documented in the CIAA (Confederation of the Food and Drink Industries of the EU) document 'Stakeholders Proposals for a Strategic Research Agenda 2000-2006'.

Teagasc, Ashtown Food Research Centre (AFRC), is involved in a pan-European research project to help address this need by analysing the food chain in six European countries (Finland, Germany, Ireland, Poland, Spain and the UK). The project, known as FOODCOMM, will help identify the key factors that influence economic relationships and communication within food chains and identify the economic, cultural and social factors that influence co-ordination within these chains. The objective is to analyse the role (prevalence, necessity and significance) of these relationships, and the level of co-ordination and communication in selected European food chains, with a view to developing sustainable economic relationships and ultimately improving returns to all members of the chain. Within FOODCOMM, simultaneous research will be conducted across Europe, providing the opportunity for cross-country analysis. In total, 13 agri-food chains will be examined across six EU countries: three cattle-to-beef chains (Ireland, Poland and the UK); two barley-to-beer chains (Germany and the UK); three cereals-to-bakery products chains (Finland, Germany and Spain); and five pig-to-pigmeat/pigmeat products chains (Finland, Germany, Ireland, Poland and Spain).

FOODCOMM will help identify the key factors that influence economic relationships and communication within food chains, and identify the economic, cultural and social factors that influence co-ordination within these chains.

Beef and pigmeat supply chains

In Ireland, relationships and communication in the Irish beef and pigmeat sectors will be analysed by a team from the Food Marketing Research Unit in the AFRC. The Irish beef sector provides an interesting focus for study, due to its high export orientation and relative value in EU terms. Similarly, the Irish pigmeat sector is a relevant study point due to the fact that it is one of the few commodities for which trade has not been significantly distorted by the CAP.

Traceability and quality assurance schemes are forcing communication along the chain and help to initiate trust and commitment to strengthen economic relationships.

Initially, a review of both meat sectors was carried out to help the development of a questionnaire in the next phase of the research and also to provide context for analysis and discussion. Both the Irish pigmeat and beef sectors were reviewed in terms of their structural organisation, economic relationships, and sector-specific cultural and political influences at producer, processor and retail level. The information was based on secondary sources (e.g., industry and trade reports) and supplemented by in-depth interviews with representatives from trade organisations or representative bodies, and comprised personnel from the farming, processing and retailing sectors of the industry. This review highlighted that both Irish chains are characterised by restructuring at producer and processor level. This trend was strongly influenced by CAP reform in the beef sector, while market factors were more influential in the pigmeat sector. Environmental and animal welfare regulations were also influential in the pigmeat sector.

Most interactions between farmers and processors in both chains occur in the spot market, with price the main variable influencing the exchange. Contract production is a minor feature of the beef sector when beef producers produce specific types of animals for a particular market (accounting for approximately 10% of slaughterings) and both sectors have some backward integration by processors, largely as a buffer against significant price variation. The power balance in both chains is skewed towards the retail multiples. However, branding in the pigmeat sector is helping to offset the retailers' power over the processor, as all retailers stock the main branded Irish cured pork and processed pork products, suggesting that multiple retailers will have a long-term, formal

New market developments present challenges and opportunities for all food businesses, from farmers to retailers.

relationship with at least two of the main Irish pigmeat processors. Branding is not a strong feature of the beef sector due to its commodity orientation.
The importance of communication along both chains is increasing as a result of technological, socio-economic and, most notably, regulatory factors. Traceability and quality assurance schemes are forcing communication along the chain and help to initiate trust and commitment to strengthen economic relationships. Horizontal relationships between farmers in both chains tend to be personal and social in nature. As relationships move closer to the retailers they become more formal and higher levels of sophisticated communication tools are employed.

The key objectives of this survey are to discover what those who produce, process and sell beef and pigmeat think about their commercial relationships, and to assess what room there is for improvement in the way in which buyers and suppliers communicate with one another.

Improving communication

The current stage of the research involves collecting direct information from the marketplace to describe the role of economic relationships and communication from the perspective of the main actors in the food chain – farmers, processors and retailers. This will involve surveying approximately 75 farmers, 25 processors and up to 20 retailers (to include multiple retailers, independent butchers, symbol groups, etc.) in both the beef and pigmeat chains. The key objectives of this survey are to discover what those who produce, process and sell beef and pigmeat think about their commercial relationships, and to assess what room there is for improvement in the way in which buyers and suppliers communicate with one another. The aim is to suggest ways of improving communication in order to drive up quality and drive down costs in the supply chain. The survey results will be analysed to highlight the role of economic relationships and communication in the beef and pigmeat chains. The results should also help identify the economic, social and cultural factors that influence the relationships.
Once this information has been analysed, further in-depth interviews will be conducted with sector representatives to tease out country-specific issues and obtain a better understanding of the findings from the previous research stages. Examples of the specific issues addressed within this in-depth research could include the rationale behind adopting state-of-the-art communication technology, and the level of uptake and impact of quality assurance schemes.

Possibilities for change

Based on the overall findings, evidence-based policy recommendations within the context of a reformed CAP will be derived, which will identify, in particular, the areas and means of improving economic relationships and communication in EU food chains. Other recommendations relating to agri-businesses, in areas such as chain operation and performance, business interaction and support systems, will also be made.

Acknowledgements

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Multifunctionality and Irish agriculture

Multifunctional agriculture is a key issue for developing agriculture and rural development policies. JOANNE BRANNIGAN and DR LIAM DUNNE describe Teagasc's involvement in a major EU project in this area.

Agriculture and rural development continue to dominate debate about rural Ireland. Farmers play a multifaceted role in this. At the individual farm level, they are primary producer, business manager, environmental manager and consumer. Beyond the farm gate, the farmer also provides labour and non-farm services to other non-agricultural sectors. The multidimensional nature of agriculture is evident, but is not always formally recognised or rewarded. Furthermore, policy instruments for encouraging such developments in a formal and structured way are limited. The TOP-MARD project ('Towards a Policy Model of Multifunctional Agriculture and Rural Development'), being carried out by Teagasc's Rural Economy Research Centre, is exploring these policy gaps and, based on the changing role of agriculture, considering the implications for agriculture and rural policy development in the future.

Multifunctionality and policy

Some aspects of multifunctionality were incorporated into the Mid-Term Review (MTR) of the Common Agricultural Policy in 2003. These include shifting to the Single Farm Payment (SFP) method of income support, with related cross-compliance and, possibly more significant in the longer term, the agreement to transfer a portion of the EU farm budget from commodity market supports to the Rural Development Programme (RDP). Under the MTR agreement, the existing commodity-based direct payments received by farmers were decoupled and converted to form the SFP. Eligibility is linked to conformity with obligatory compliance conditions in relation to environmental protection, animal health and welfare, plant health and public health. Furthermore, through compulsory modulation during the transition to the SFP, a portion of the historic payments was transferred to the RDP budget. Consequently, public support for rural development policies facilitates continued agricultural restructuring, sustainable development of rural areas, and a balanced relationship between the countryside and urban areas.

The concept of multifunctionality was also debated in the wider international arena through the Rio Convention of 1992 and in a publication by the Organisation for Economic Co-operation and Development (OECD) in 2001. More recently, it has emerged as a contentious justification for protectionism or 'non-trade concerns' within World Trade Organisation (WTO) negotiations.

Multifunctionality in practice

In the current policy context, the role of multifunctionality within agriculture and rural development is becoming increasingly apparent. The production function of agriculture, realised in commodity outputs, has traditionally been rewarded either directly through the market or indirectly through market supports. In addition, non-commodity outputs are identified due to interactions between multiple functions in agriculture and other rural sectors. Such outputs may be tradeable and rewarded through the market, or non-tradeable, resulting in no market return to the producer. An example of a tradeable function is pluriactivity, where waged labour from the farm household is provided to other economic sectors through off-farm employment. Non-tradeable functions, on the other hand, are classed as public goods, for example, rural landscapes, biodiversity, food safety, food product quality and sustainable rural development. However, non-tradeable functions can also be negative in their impacts, for example, pollution.

From a policy perspective, the supply of positive non-tradeable goods and services produced by farming and farm households can be increased by appropriate policy instruments and initiatives. Farmers could be encouraged and motivated to continue and/or increase production of such desired outputs. In parallel, regulation is necessary to prevent or reduce undesired non-market outputs such as water or air pollution or reduced biodiversity, and to prevent over-exploitation of non-renewable resources such as water or soils in the food and fibre production process. Supply characteristics of multifunctional outputs will vary between places depending on the volume and composition of natural resource endowments, the level and method of their economic exploitation, and related regulation.

A 'consumer' policy interest exists in the impacts of multifunctionality on development of rural localities and regions. Similar to the supply characteristics, consumer interest will vary between places. For example, an optimum balance may exist between tourism, recreation and food production, but this balance is likely to vary greatly between regions. Thus, an understanding of the impacts of multifunctional agriculture on rural development is necessary at local and regional levels.

Increasing the functional use of land includes leisure and recreational activities.

TOP-MARD involves a structured examination of the relationships between potential or actual policy changes, alongside associated changes in the multiple functions of agriculture and sustainable development of rural areas.

TOP-MARD project

The TOP-MARD project was devised and launched in March 2005. Its aims are to:

- develop and test the concept of multifunctionality as a rural development instrument sensitive to economic, social, cultural, environmental and geographical contexts in the EU;
- make a contribution towards development of EU policy related to agriculture and rural development, social cohesion and trade; and,
- provide a basic model to help facilitate policy targeting.

The project involves a structured examination of the relationships between potential or actual policy changes, alongside associated changes in the multiple functions of agriculture and sustainable development of rural areas. The EU project involves 11 countries, thus producing country-specific results and enabling cross-country and European-wide comparison and analysis.

Irish study area – County Mayo

Disparate study areas within Europe will be used to explore the diversity of multiple functions, outputs, and subsequent impacts of multifunctional agriculture on rural development at a regional level and across Europe. County Mayo was selected as the Irish study region. Although still significantly dependent on agriculture as a primary industry, clear and visible signs of restructuring are apparent, including increased diversity on farms through pluriactivity, environmental management, and on-farm enterprise diversification. Supplementing farm incomes through other non-farm activities is now much more prevalent. Rural areas in the county are experiencing changes; population is declining in the more remote areas while rural regions closer to urban areas are influenced by development and employment opportunities. Farmer participation in agriculture is also re-adjusting, due to employment opportunities in the non-farm economy, combined with the need to underpin farm incomes in the context of substantially reduced market supports. This is leading to less time spent on the farm and rationalisation of on-farm activities.

Approach

Fieldwork for the project is now in progress, and testing and further elaboration of concepts and scenarios will follow. Primary data will be collected through structured interviews with: farmers, rural entrepreneurs, key organisations and community groups.

Within the county, data will be collected concerning the multiple functions of agriculture, the inter-relationships with other economic sectors, and the commodity and non-commodity outputs, both tradeable and non-tradeable. Subsequent to the data analysis and cross-country comparisons, recommendations will be made. Central to this will be the amelioration of negative non-commodity outputs of farming, and rewards for land-users – either through the market or by other mechanisms – for production of desirable non-food and fibre outputs.

Funding

The TOP-MARD project is funded under the EU Sixth Framework Programme. The project partnership consists of institutions in Austria, Germany, Greece, Hungary, Ireland, Italy, Norway, Scotland, Slovenia, Spain and Sweden.

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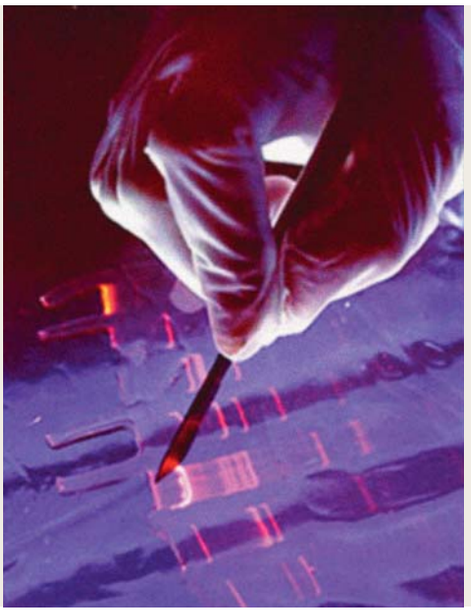
New era in bovine genomics

The availability of the entire sequence of the bovine genome will play a central role in the way we conduct bovine genomic research for decades to come. RICHARD FITZPATRICK explains how recent advances in bovine genomics are being used to improve our understanding of the molecular mechanisms involved in the metabolic disorder, negative energy balance.



DNA testing for economically important traits (image courtesy of Pacific Northwest National Laboratory).

Improving animal health, reproduction, production and product quality are major goals of the beef and dairy sectors. Such traits have complex physiology and are controlled by multiple gene expression events, in a variety of different tissues at different stages of the animal's lifespan, thus making them difficult to improve by classical breeding. The complex nature of these traits also mean they are difficult to study using traditional molecular techniques, which typically can only measure the expression of a small number of genes, one at a time.

Genomic research, the branch of science that links genes and gene regulation to physical appearance or 'phenotype', provides an important approach for identifying trait-associated genes and the factors that alter their expression. Recent advances in bovine genomics have significantly improved our ability to identify trait-associated genes and to understand the link between multiple gene expression events and economically important traits.

In August 2006, a high quality sequence of the bovine genome was completed, assembled and released into the public DNA databases, at a cost of $53 million. It is now known that the bovine genome contains approximately 3 billion DNA base pairs, which is similar in size to the human genome, and is expected to encode 30,000 to 40,000 genes. However, only a small percentage of these genes code for economically important traits. The challenge is to identify these trait-associated genes and to determine how they are modified by environmental influences. This is an enormous task, which is made even more difficult given that the function of most genes is either unknown or poorly understood. The availability of the entire sequence of the bovine genome will accelerate gene discovery and will play a central role in the way we conduct bovine genomic research for decades to come.

Molecular techniques

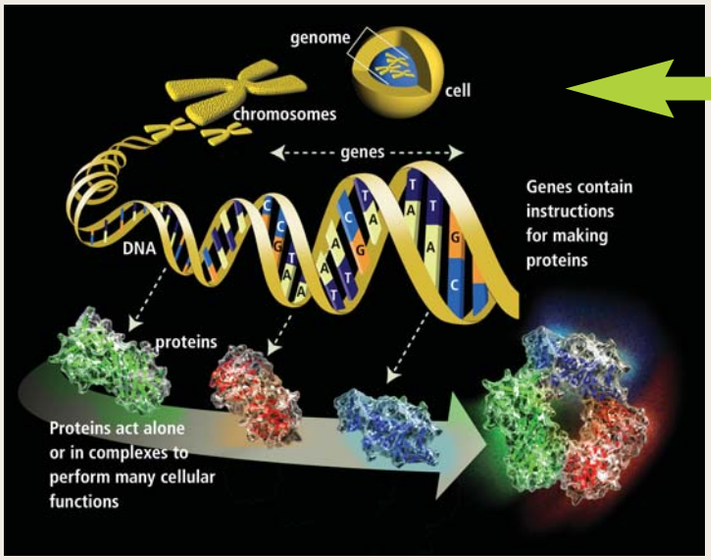
Technologies for scanning billions of base pairs of DNA are also accelerating bovine gene discovery and are helping to unravel the molecular mechanisms controlling economically important traits. All bovine cells (with the exception of red blood cells and certain reproductive cells) contain the capacity to express the estimated 30,000 to 40,000 genes encoded by the bovine genome. However, only a subset of these genes (approximately 12,000) is expressed in any one individual cell.

A major challenge for genomic research is to identify the unique pattern of gene expression that determines trait characteristics and to identify the key genes involved. Micro-array technology permits the expression analysis of thousands of genes simultaneously in a single experiment, and is proving to be an effective approach in understanding the intricate co-ordination of multiple gene expression events and how key biological processes are regulated. It is anticipated that this information will lead to new hypotheses and identify novel ways to improve bovine traits.

Technologies for scanning billions of base pairs of DNA are accelerating bovine gene discovery and helping to unravel the molecular mechanisms controlling economically important traits.

Important traits

For example, a better understanding of the genes regulating production and quality traits is an important first step in enabling the identification of relevant molecular markers to accurately select animals with increased potential to produce quality beef and dairy products. This is a growing area of research and there are already 11 DNA diagnostic tests available, which are being marketed on the basis of their ability to identify animals that have increased potential to produce quality traits, such as meat marbling/tenderness, or to increase milk protein/fat content.



Advances in bovine genomics are helping to unravel the relationship between gene expression and phenotype.
(Image credit: US Department of Energy Human Genome Program, http://www.ornl.gov/hgmis and Australian Gelbvieh Association Inc.).

Similarly, a better understanding of the genes involved in nutrient partitioning, and knowing which genes come into play when animals are metabolically stressed, will help in the development of new nutritional and/or management systems to promote animal health, production and quality traits.

Negative energy balance

This approach is now being used at the Teagasc Animal Production Research Centre in Athenry to gain new insights into a common metabolic disorder of the early lactation dairy cow – negative energy balance (NEB). NEB affects high-yielding dairy cows during the early post-partum period, and has been implicated as a cause of both impaired cow health and fertility.

During the early post-partum period, the energy demands of lactation exceed energy intake and cows enter a period of NEB. To offset this energy deficit, fat and protein reserves are mobilised. This is accompanied by increased accumulation of fatty acid by-products, such as non-esterified fatty acids and β-hydroxybutyrate, which in severe cases can compromise liver function and result in production diseases such as ketosis or fatty liver.

Understanding why some high-yielding cows successfully cope with NEB, while others experience metabolic, health and fertility problems, requires a better knowledge of the underlying molecular mechanisms. To provide new insights into this problem, a 23,000-gene micro-array (the most comprehensive set of bovine genes to be assembled) was used to study the effects of NEB on liver gene expression in high-yielding dairy cows during the early post-partum interval.

Gene variation

Results to date indicate that cows in severe NEB have increased liver triacylglyceride concentrations compared to cows in mild NEB. Also, cows in severe NEB show elevated expression of key genes involved in inflammatory response and reduced expression of genes involved in cellular proliferation, which is likely to compromise adaptation and recovery from NEB. A high concentration of lipids is known to induce cellular trauma and inflammation response, and also to repress the expression of genes involved in cellular proliferation. These results suggest that reducing hepatic lipid accumulation during the early post-partum period, through the formulation of improved nutritional strategies, may help reduce inflammatory response and improve cellular proliferation, thereby hastening adaptation and recovery from NEB. From this study we have also identified the key liver genes involved in lipid metabolism during the early post-partum interval. Identifying variations of these genes, which increase a cow's capacity to metabolise or mobilise liver lipids, has potential application as a molecular diagnostic test for the identification of animals that are either more or less tolerant to the effects of NEB. These tests would be valuable tools in future animal breeding programmes.

Improving economically important traits

Developments in bovine genomics are changing the way we address biological problems and providing us with new opportunities to understand and improve animal traits. They are also allowing us to generate new information and new insights into the underlying mechanisms regulating essential biological processes. In the long term, this information has the potential to be exploited by emerging biotechnologies to improve economically important traits.

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Diets for enhancing cow fertility

Omega-3 fatty acid supplementation modifies the expression of key uterine genes involved in cow fertility. SINÉAD M. WATERS describes her work in this area.

Feeding omega-3 PUFAs alters the genes associated with fertility.

The modern high-producing dairy cow is sub-fertile, and this loss in cow reproductive performance costs the Irish cattle industry an estimated €200 million annually. Early embryo loss, within the first 16 days of gestation, is the greatest contributor to reproductive wastage, though the causes for this are not well defined. At the Teagasc Animal Production Research Centre in Athenry, molecular-based approaches are being adopted in an attempt to identify the causes of low embryo survival rates in cows.

Nutrition is widely acknowledged as having a fundamental influence on embryo survival. Attempts to improve dairy cow reproductive performance by increasing dietary energy density have traditionally focused on increasing the carbohydrate or fat content of rations. However, this approach leads to greater milk production and increased metabolism, and has serious implications for rumen function, cow health and productivity.

Long chain omega-3 polyunsaturated fatty acids (ω–3 PUFAs) are potent molecules that have been shown to support important cellular processes, including membrane stability, gene transcription, cell adhesion and proliferation, and intracellular prostaglandin transport. Sources of these ω–3 PUFAs include fish meal, fish oil and algae.

A number of studies in which dairy cows have been supplemented with a source of ω–3 PUFA (i.e., fish oil) have reported beneficial effects on reproductive performance. There is also evidence from *in vitro* cell culture studies that the ω–3 PUFAs eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), play pivotal roles in the suppression of uterine-derived prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) synthesis, a critical regulator of embryo survival, though the biochemical mechanisms involved are as yet unclear. While the uterine environment is critical to embryo survival, and despite a role for dietary ω–3 PUFAs in the regulation and support of pregnancy, there is no information on its effects on genes known to be involved in reproduction-related mechanisms and pathways.

Supplemental PUFAs

In a recent study at Athenry, heifers were fed diets supplemented with a rumen-protected source of either saturated fatty acid (palmitic acid – low ω-3 PUFA) or EPA/DHA (high ω-3 PUFA) for 45 days. Feeding the encapsulated high ω-3 PUFA supplement increased the EPA and DHA concentrations in the uterine endometrium. In fact, combined EPA and DHA endometrial concentrations were more than two-fold higher in the animals fed the high ω-3 PUFA diet compared to those on the low ω-3 PUFA diet, while EPA concentrations only were more than four-fold higher in the animals on the high ω-3 PUFA diet. Furthermore, concentrations of arachidonic acid, the main substrate for $PGF_{2\alpha}$ synthesis, were 40% lower in tissues from the high ω-3 PUFA group. A reduction in endometrial concentrations of arachidonic acid in animals supplemented with high ω-3 PUFAs suggests that EPA and DHA acted as alternative substrates in the prostaglandin synthesis cascade and reduced the lipid pool of arachidonic acid in the endometrium, potentially leading to a decrease in the concentration of $PGF_{2\alpha}$. This dietary approach successfully modulated endometrial concentrations of the key ω-3 PUFAs, clearly showing the potential of this animal model.

Of the 10 genes examined, three were identified as being significantly up-regulated in animals on the high PUFA diets.

Gene expression

Uterine endometrial tissue was harvested from animals on the high and low PUFA diets, messenger ribonucleic acid (mRNA) was isolated, and the gene expression profiles of 10 candidate genes coding for proteins involved in prostaglandin biosynthesis were analysed using real time polymerase chain reaction (PCR) (**Figure 1**). Of the 10 genes examined, three (prostaglandin E_2 synthase [PGES] and the peroxisome proliferator-activated receptors δ and α [PPAR-δ and PPAR-α]) were identified as being significantly up-regulated 2.8-, 1.47- and 1.57-fold, respectively, in animals on the high PUFA diets. The gene expression of the enzyme phospholipase A_2 (PLA_2) was also shown to

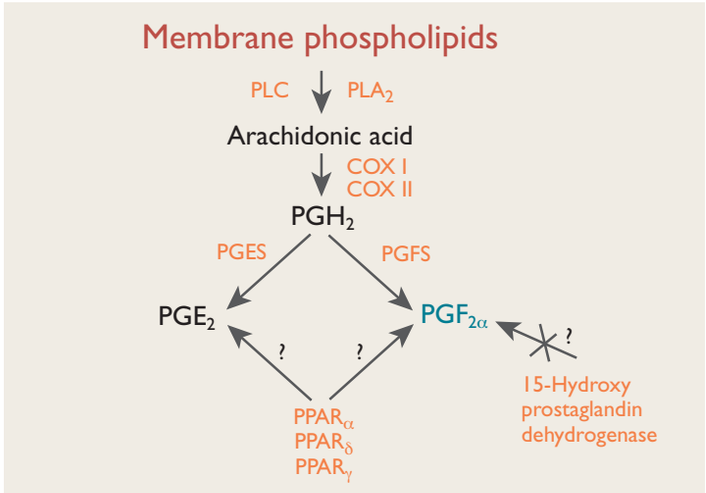

FIGURE 1: Candidate genes targeted in the endometrial tissue of cows supplemented with ω-3 PUFAs.

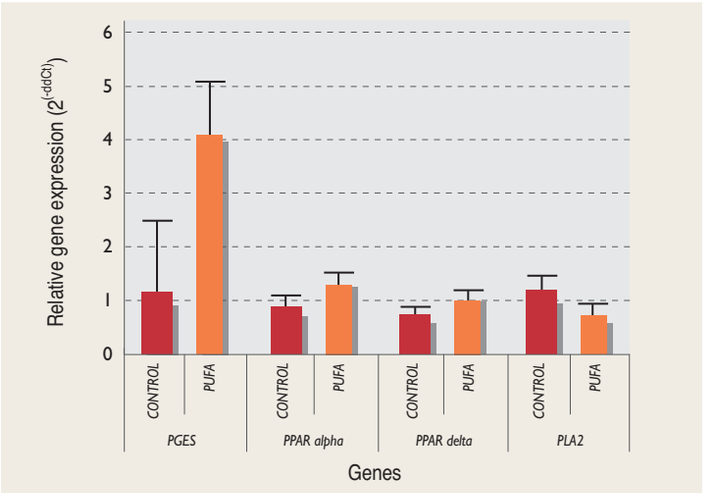

FIGURE 2: Effect of dietary supplementation of ω-3 PUFA on mRNA expression of endometrial genes involved in prostaglandin biosynthesis.

be decreased 2.1-fold in animals fed diets containing high PUFA concentrations (**Figure 2**). The other six candidate genes were not differentially expressed.

Up-regulation of PGES mRNA expression suggests that ω-3 PUFA supplementation increases PGES enzyme concentrations, which, in turn, augments endometrial prostaglandin E_2 (PGE_2) production. PGE_2 in uterine fluid has been previously reported to be associated with enhanced embryo development and survival rates in cattle.

These studies show, for the first time, a potential biological basis for the reported putative effects of dietary ω-3 PUFAs on enhancing embryo survival rates in cattle.

Peroxisome proliferator-activated receptors (PPARs) are ligand-activated transcription factors that regulate multiple physiological processes, including inflammation, development and lipid metabolism. Evidence exists to suggest that some of the beneficial effects of ω-3 PUFAs on fertility may be mediated through PPAR activation, since ω-3 PUFAs are ligands for PPARs α, γ and δ. PPAR-α and δ have previously been shown *in vitro* to function in the bovine endometrium in response to long chain fatty acids, and were shown to be involved in the regulation of prostaglandin synthesis. In mice, PPAR-δ deficiency has led to placental defects and resulted in frequent mid-gestational lethality, suggesting that this nuclear receptor may play an important role in the control of the reproductive process in mammalian species. In fact, there is further evidence to suggest that PPAR-δ is involved in the pregnancy recognition process of cattle, and that it mediates at least some of the beneficial effects of long chain ω-3 PUFA supplementation. $PGF_{2\alpha}$ is derived from arachidonic acid found in cell membrane phospholipids. The enzyme PLA_2 is involved in the initial step in the mobilisation of arachidonic acid, the substrate for $PGF_{2\alpha}$ production, from the phospholipid membrane. A decrease in its expression concurs with the noted decrease in arachidonic acid concentrations measured in the endometrium. This result indicates that less $PGF_{2\alpha}$ was produced, potentially enhancing embryo survival rates.

Nutrition for embryo survival

This is the first published report showing that the endometrial genes PGES, PPAR-α, PPAR-δ and PLA_2 are differentially expressed following high dietary ω-3 PUFA intake in an *in vivo* animal model. Due to the critical role of $PGF_{2\alpha}$ in controlling corpus luteum regression, and hence early embryo survival, the identification of these changes in gene expression in the endometrial tissue of animals fed with ω-3 PUFAs marks a major advancement in our understanding of the biological mechanisms by which this nutritional supplement can affect the establishment and maintenance of pregnancy in cattle.

These studies show, for the first time, a potential biological basis for the reported putative effects of dietary ω-3 PUFAs on enhancing embryo survival rates in cattle. Furthermore, it demonstrates the usefulness of employing a molecular approach to gain a better understanding of a complex problem. It also highlights the importance of a good animal model for molecular studies. Studies as described here have significant potential to further the understanding and development of nutritional management strategies, which may ultimately be integrated with reproductive management programmes to increase cow fertility.

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Fighting back with fungi

A large percentage of pesticides used in the hardy nursery stock industry is applied to control the black vine weevil. MICHAEL GAFFNEY at Kinsealy Research and Development Centre describes a possible biological control.

Vine weevil larvae at various stages of colonisation with Metarhizium.

The larvae of the black vine weevil are one of the most serious pests of the hardy nursery stock (HNS) and soft fruit industries. The larvae feed extensively on the root systems of hundreds of different varieties of plants, and unfortunately, by the time symptoms of larval damage become apparent, such as wilting, much, if not all, of the root system has been destroyed, usually rendering the plant unmarketable. This means that preventive treatment has always been the norm for vine weevil control. In 2005, 66% of the total weight of pesticides applied in the HNS industry was applied to control the larvae of the black vine weevil. Therefore, finding a reliable biological alternative to chemical control would drastically reduce pesticide inputs in the sector.

The black vine weevil

Adult vine weevils initially emerge into nurseries in May and June. They then spend up to eight weeks feeding while their ovaries mature. They are nocturnal insects, feeding at night and hiding in crevices during the day. The adult has fused wing casings, making it unable to fly. If disturbed while feeding or hiding, a vine weevil adult will automatically drop to the ground and lie still with its legs and antennae pulled in against its body. It will remain like this for a few seconds, or even a few minutes, before first extending its antennae, and then eventually extending its legs and walking off to find cover. This is known as catalepsis, and is thought to be a self-defense mechanism, making it difficult for predators to locate the adult vine weevil. Adults are rarely seen in daytime and the characteristic feeding notches on the leaf margins are not always obvious, especially in large nurseries with thousands of plants. Therefore, the first indication of vine weevil infestation is usually dramatic wilting of plants in the spring following the incursion of adults into the nursery and by then the damage caused can be extensive.

Vine weevil adults are all female and they reproduce asexually, that is, they lay fertile eggs without the need to mate, laying up to 1,500 eggs over a three month period, usually from July to September. The survival rate of eggs to larvae is usually high, which means that plants can be exposed to several larvae at the same time. The life cycle of the insect from egg to adult includes several 'instar' larval stages. In some countries, such as the US, the vine weevil has seven larval instars, whereas in Ireland and the UK, it seems to have six. Damage caused by early instar larvae is not that injurious to the plant. However, extensive damage is caused by the later larger instar larvae, as they feed heavily on the larger roots of the plant.

Chemical control of the black vine weevil larvae is achieved by treating the soil with the insecticides, chlorpyrifos or imidacloprid, to kill the larvae. Entomopathogenic (pathogenic to insects) nematodes can also be effectively used for vine weevil control, but due to the biological nature of these products, they can suffer from application and consistency problems.

The first indication of vine weevil infestation is usually dramatic wilting of plants in the spring following the incursion of adults into the nursery and, by then, the damage caused can be extensive.

Biological control

Entomopathogenic fungi have been investigated as possible biological control agents since 1878, when Elias Metchnikoff first isolated a strain of *Metarhizium anisopliae* from an infected wheat chafer (beetle), *Anisoplia austriaca*. *Metarhizium* and other entomopathogenic fungal species, such as *Beauveria* and *Verticillium spp.* occur ubiquitously around the world in alternating life

stages between a soil saprophytic (free living) stage and an insect pathogenic (lives on the insect) stage. These fungi kill insects by attaching themselves to the cuticle of the insect and growing into it.

When a larva comes into contact with a saprophytic conidium (asexual spore) in the growing medium or soil, the conidium attaches itself to the insect cuticle by hydrophobic and electrostatic interactions. Then, providing the right environmental conditions are present, the conidium germinates and forms an appressorium or penetration plug. Under the appressorium, a germ tube starts to grow into the cuticle by means of mechanical weight and cuticle-degrading enzymes mediated by the PR1 (pathogenesis-related) gene. Once the germ tube reaches the body cavity of the insect, the fungus forms blastospores, which disperse throughout the insect. The insect is killed by a combination of the physical disruption to its internal organs and toxicity caused by a group of cyclic depsipeptides, called destruxins. Destruxins disrupt calcium channels and inhibition of vacuolar-type ATPase. At this stage, mycelium within the insect cadaver continues to grow until it eventually breaks through the intersegmental joints and sporulates to produce more infective conidia on the surface of the insect.

Due to the promising results achieved at Kinsealy, commercial trials are currently being conducted at nurseries both here and in the United Kingdom.

Commercial development

Several problems have arisen in previous attempts to develop and commercialise fungal entomopathogens. They are expensive to produce, can have limited persistence, and infection of larvae can be inconsistent below 15°C – a factor that may hinder the usefulness of such fungi in cooler climates and seasons. New production techniques, involving manipulating the ratio of carbon to nitrogen in the fungal growing substrate, have helped improve virulence of conidia. Also, a better understanding of the virulence genes involved has helped to greatly improve consistency and lower the cost of production. The selection of more tolerant strains has helped improve efficacy at lower temperatures, although infection rates of larvae below 10°C are still very poor.

Group of adult vine weevil.

Killer fungi

At Teagasc Kinsealy, our main objective has been to test the efficacy of various fungal isolates (*Metarhizium* and *Beauveria spp.*) in infecting and killing the vine weevil larvae outdoors. In particular, one strain of *Metarhizium* has been shown to give good control of larvae over numerous trials. The fungus can be applied to growing media as either a drench or a premix. There was no statistical difference in larval mortality between either application method. When either a premix or drench application of *Metarhizium* was applied, control was over 70%, comparable with chemical control and entomopathogenic nematode control. It was decided to focus our research on premix application, as this would reduce labour inputs at the nursery and allow the growing medium supplier to have good control over the application rate. This should help to provide consistent results, as the actual amount of conidia to be added can be very low (less than 0.5g for every 50 litres of growing medium).

Very consistent control using only a premix application of *Metarhizium* has been achieved with this fungal isolate over a range of plants, such as *Primula*, *Begonia*, *Astilbe*, *Azalea*, *Euonymus* and *Fuchsia*, all varieties that are particularly susceptible to vine weevil damage. Control has also continued into the second growing season. Our work at Kinsealy has shown that although the number of conidia remaining in the growing medium after 12 months decreased by 87%, it did not lead to a significant decrease in larval control. However, if we started with 90% less inoculum, this did lead to a significant reduction in larval control. We believe this discrepancy can be explained by a starvation effect on the fungi. We believe that as the endogenous reserves of carbon and nitrogen in the fungal conidia are used up, the conidia becomes more virulent, with the genes that initiate attachment and infection of the larval cuticle becoming heavily expressed. This could mean that the older conidia are more virulent than newer inoculum.

Due to the promising results achieved at Kinsealy, commercial trials are currently being conducted at nurseries both here and in the United Kingdom. While more field evaluations need to be carried out – especially in commercial nurseries – results so far hold some promise for an economically viable fungal biocontrol option for the control of black vine weevil larvae in the near future.

Acknowledgements

The author is grateful to Dr Gordon Purvis (UCD), Dr Richard Dunne and Michael Maher (Teagasc), and also to Dr Munoo Prasad (Bord na Móna), for their advice and input into the work done so far. I am also grateful to Drs Tariq Butt and Farooq Shah of the University of Wales, Swansea, for providing fungal material.

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Michael Gaffney completed this work as part of a Teagasc Walsh Fellowship. He is currently working as a Horticultural Development Officer at Teagasc, Kinsealy Research & Development Centre, Dublin.

Breeding new potato varieties

Over 30 potato varieties have been developed at Teagasc, Oak Park, including the popular Rooster and Cara varieties. DENIS GRIFFIN and LESLIE J. DOWLEY describe the process involved in developing a new variety of potato.

Potato flowers possess both male and female sex organs.

Potato is the fourth most important food crop in the world after wheat, rice and maize, and the area under production worldwide is rising faster than that of any other crop due to its high yield potential and excellent nutritional characteristics. Potato is of particular importance in Ireland where it is still the primary carbohydrate source at main meals, whereas bread, pasta and rice tend to be the main sources in the rest of Europe.

The potato breeding programme at Teagasc, Oak Park, Carlow, commenced in 1962. The original objective was to breed a high-yielding, late blight-*(Phytophthora infestans)* resistant variety for the Irish market to replace the traditional varieties such as Kerr's Pink and Record.

With the introduction of plant breeders' rights in the 1970s, increased demand for export varieties was experienced and the aims of the programme quickly diversified. A partnership was formed soon after with Irish Potato Marketing to exclusively market Teagasc varieties, which has led to commercial success and stability for one of the organisation's longest running funded programmes. The introduction and subsequent success of the Cara variety secured the future of potato breeding at Oak Park. Cara was grown widely in Ireland, mainly for seed export and, at the height of its success, it accounted for over 10% of the total ware area (for consumption) in the UK. Over 30 varieties have been released in the intervening period, with eight of these (Camelot, Galactica, Kikko, Setanta, Habibi, Nectar, Carnaval and Savanna) in the last five years. Rooster is the best known of the Oak Park varieties due to its status as the most popular potato variety in Ireland. Since its release in 1991, the area under production has grown to over 40% of the total potato ware area in Ireland today. The success of Rooster is due largely to its excellent taste and cooking quality, as well as its superior agronomic characteristics. Today, varieties are bred for the home market, for export trade and for the processing industry.

The challenge

The breeding process for potatoes can take up to 15 years, from initial crossing to delivery and commercialisation of a new variety. This means that breeders must predict the traits that will be important in 15 to 20 years time to meet demand and ensure the success of new varieties. The important traits for potato have changed over the years. Flavour and texture were once considered the most important attributes. The advent of washed potato displays in supermarkets require varieties that also exhibit good tuber shape and uniformity, smooth unblemished skin texture and shallow eyes. The consumption of fresh potatoes is also falling, with more potatoes being consumed as fried or processed product. Specialist varieties with low reducing sugar content are required for this processing market.

The potato is susceptible to a wide range of pests and diseases, many of which cause serious yield penalties (late blight, blackleg and potato cyst nematode), with others that affect skin quality and marketability (common

Potato berries formed from fertilised potato flowers containing true potato seed.

True potato seed extracted from a single berry.

Progeny tubers derived from a single family or 'cross.' All tubers share the same parents but are genetic individuals.

scab, black scurf and silver scurf). While chemical control is available for many of these diseases, this approach is becoming less favoured by consumers and regulators. Many novel disease resistance traits are available in wild relatives of the cultivated potato, and introgression of these traits by conventional methods has been very successful over the last 30 years, leading to increased disease resistance in many new varieties. This has the ability to lower pesticide inputs and could have a significant role in organic production systems. Many Oak Park varieties have very high levels of blight resistance, especially two recently developed varieties, Orla and Setanta. These varieties are suitable for organic and conventional production. Setanta has very good eating quality, fry colours and also very high levels of resistance to storage diseases. Orla is a second early variety and is unusual in being one of the very few early varieties to exhibit high levels of blight resistance. Breeding late blight- and potato cyst nematode-resistant varieties will continue to be a major goal in the future. Potato agronomy and crop husbandry techniques have also improved dramatically, and these systems require new varieties with superior phenotypes to fully exploit their yield and quality potential. Already, demand is increasing for varieties that require reduced inputs of water and nitrogen and that mature earlier in the season, allowing harvesting to take place before soils become wet and susceptible to damage.

Many Oak Park varieties have very high levels of blight resistance, especially two recently developed varieties, Orla and Setanta, making both varieties suitable for organic and conventional production.

Breeding process

Reproduction of the commercial potato crop is by clonal propagation. Each potato tuber planted is an exact genetic copy of the plant it was derived from. Potato breeding takes advantage of the production of true botanical potato seed, which exhibits high levels of genetic variation. New potato varieties are produced by combining the best characteristics from selected parents that have complementary traits. Varieties to be used as parents are grown in the glasshouse. Potato flowers possess both male and female sex organs. Flowers selected for use as females have the male anthers removed prior to maturity in a technique known as emasculation; this technique ensures that self-fertilisation cannot take place. When these flowers mature, pollen is harvested from mature whole flowers of the selected male parent and used to fertilise the emasculated flower. If fertilisation is successful, a berry will form. Potatoes and tomatoes are very closely related and the potato berry resembles a small green tomato. One berry can contain up to 200 seeds, each of which is a genetically different individual representing a potential new variety. Up to 100,000 true seeds are grown for evaluation each year in pots. Each seed produces a number of tubers, only one of which is retained for propagation in the field as single spaced plants. These seedlings are visually selected at the end of the first field season for commercial traits and only 3,000 are advanced for further evaluation. Seedlings are tested for a further eight years in the field under increasingly rigorous selection criteria. The numbers are reduced each year as more traits are scored, beginning with foliage maturity in year four and culminating with disease resistance screening, organoleptic evaluation and agronomic performance across a number of geographically diverse sites representing countries where the variety might eventually be grown. After approximately 10 years of evaluation, only one to two seedlings remain, which are entered for national list trials to determine if they are suitable for variety status and a grant of plant breeders' rights.

Future prospects

The future aims of the programme are to continue to produce agronomically superior, disease-resistant varieties, with excellent taste and consumer attributes. The traditional breeding process is constantly being re-evaluated and updated to incorporate cutting-edge technologies, such as marker-assisted selection (see *TResearch* Winter 2006; 1 (1): 28) in collaboration with the Plant Biotechnology Unit at Oak Park. The discovery of new markers and genes through Teagasc's involvement with the potato genome sequencing project will make the process of introgressing resistance traits more efficient.

Denis Griffin is a Research Officer and **Leslie J. Dowley** is Head of Department in the Crops Research Department, Teagasc, Crops Research Centre, Oak Park, Carlow.

Fuels of the future

If the Irish biofuel industry is to develop to a significant scale, and we are to avoid a scenario of replacing mineral fuel imports with biofuel imports, ways of improving the profitability of native production must be found. BERNARD RICE explores our options.

Research on energy production from biomass now has a high priority in most developed countries. The reasons for this are obvious – global warming, increasing oil prices and concerns about supply security, and declining profitability of traditional farm enterprises. In Ireland, the most likely biofuel prospects are shown in **Table 1**. They fall into two categories: liquid biofuels for diesel or petrol cars, and solid or gaseous fuels for heating or electricity production. Some of these biofuels are already being produced in Ireland; others will start up over the next few years.

Liquid biofuels

The rise in oil price in recent years is stimulating a lively consumer interest in alternative transport fuels. The Government has recently rolled out the Biofuels Mineral Oil Tax Relief (MOTR) scheme, which invited potential producers of biodiesel, pure plant oils and ethanol to submit proposals for biofuel production on which excise would be remitted. The MOTR scheme envisages the use of 163 million litres of road biofuel per annum (2% of our transport fuel usage) by 2010. If this were all produced from native raw materials, it would require about 70,000 ha of tillage land, and most of the excise foregone would be recouped as VAT, income tax, etc., generated by the additional economic activity. But, from the results of the MOTR allocation, it appears that much of the biofuel will be imported. In this case, the Irish Government will suffer the loss of excise revenue, with no benefit to agriculture and little improvement to fuel supply security. It will also result in avoidable long-distance transport of biofuels. So a big effort is required from all sides to ensure that, in future, as much as possible of our road biofuels is produced at home. For research, one of the challenges will be to reduce the cost and assure the quality of home-produced fuels, so that they can match imports in the marketplace.

Solid biofuels

The 'Bioheat' and 'Greener Homes' schemes introduced in 2006 are providing capital grant aid for the purchase of biomass boilers and stoves. These schemes have generated huge interest in biomass heating fuels and, at present, this interest is concentrated in three areas:

- **Wood chips as boiler fuel for buildings with a big, continuous heat demand, such as hotels or hospitals.**
  The chips will come initially from forest and sawmill residues. The main research challenge will be to develop handling systems that are cost efficient and also allow the residues to be air dried to an acceptable moisture level. Short-rotation willow is a medium-term possibility for this market, and establishment grants promised in the budget will generate much interest in this option.

Harvesting of the energy crop miscanthus, or elephant grass, at Teagasc, Oak Park.

Oil seed rape provides high quality raw material for biodiesel production.

- **Biomass pellets for urban residential stoves and small boilers.** Sawdust will be the preferred raw material initially for pellet production, but supplies of this material are limited. When this is exhausted, wood residues, energy crops such as willow or miscanthus, and cereal or rape straw are other possible feedstocks. Again, research will be needed to determine the suitability of these materials for the production of high quality fuel pellets.

- **Cereal grains for heating farm homes.** This will be concentrated initially on tillage farms, but may spread to other rural dwellings. Research is underway at Oak Park to determine the suitability of the various grain species and the moisture contents needed for good combustion.

A big effort is required from all sides to ensure that, in future, as much as possible of our road biofuels are produced at home. For research, one of the challenges will be to reduce the cost and assure the quality of home-produced fuels, so that they can match imports in the marketplace.

TABLE 1: Medium-term biofuel options.

Plant oil or biodiesel		
Rape-seed oil Recycled vegetable oil Tallow	→	Replace diesel
Ethanol		
Cereals Beet	→	Replace MTBE* *(oxygen enhancer)* in petrol
Bale, chop or pellet		
Wood residues Straw Grain, miscanthus Willow	→	Replace oil/gas in: Stoves Boilers Power stations

**Methyl tertiary-butyl ether*

T Crops

This generating station at Edenderry is well suited to the burning of biomass co-fired with peat; payment policy changes and research support will be needed for a smooth transition.

Biogas

The production of biogas from animal manure, food wastes and energy crops is expanding rapidly in Germany. The gas is mainly used in boilers or combined heat and power plants. A combination of low green electricity prices and animal health concerns with food wastes has militated against development in Ireland to date. But with looming organic waste disposal problems, we need to start researching every option for its utilisation as a biofuel feedstock.

Co-fuels

We are at the beginning of an interest in the use of biomass as a co-fuel at the modern peat-burning electricity plants. These stations burn a total of three million tonnes of peat per year. The recent Green Paper, 'Towards a Sustainable Energy Future for Ireland', sets a 30% biomass substitution target for these stations. Allowing for differences in calorific values, this would require about 700,000 tonnes of biomass; a daunting but achievable target. To allow this development to get underway, action is needed on two fronts:

- the price currently paid for peat would not cover the cost of producing energy crops. The payment system must be modified to allow the saving in carbon credits to the electricity producer to be used to top up the raw material price paid to the grower; and,
- to minimise the cost and environmental impact of long-distance transport of bulky material, production would have to be concentrated close to the power stations. All the impacts of such a development need to be researched carefully, and an appropriate mix of energy crops developed. Intensive local energy crop production could affect catchment hydrology, scenic aspects, biodiversity and local traffic. Careful planning and species selection would be needed to overcome these problems. The social benefits of providing alternative employment for workers currently engaged in peat harvesting would be substantial.

Changing landscape

So some opportunities are beginning to emerge for the transfer of significant areas of land from food/feed production into energy crops. This will bring improvements in our energy supply security and greenhouse gas balance; a reduction of food/feed production should also help to stabilise prices for these products. But, there is still a major problem in that the profitability of producing and processing biofuel crops remains very low. If the industry is to develop to a significant scale, and if we are to avoid a scenario of replacing mineral fuel imports with biofuel imports, ways of improving the profitability of native biofuel production must be found. This will require a number of changes at policy level and an intensive research effort at a number of levels. The main areas in need of immediate research are concerned with: agronomy and cost of feedstock crop production; profitable utilisation of the by-products of biofuel production and processing; the quality of native and imported solid and liquid biofuels; and environmental impacts of more intensive energy crop production. In the longer term, systems for small- to medium-scale electricity production from biomass and for liquid biofuel production from the cellulose component of plants, will be approaching commercialisation and will need to be evaluated.

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T Events

Science Events

March
6-7 *Dunboyne, Co. Meath (March 6); Clonmel, Co. Tipperary (March 7)*

'Farming Fuel from the Land' – Renewable Energy Conference

Joint Teagasc/Department of Agriculture and Food conference. There will be a review of government policy on renewable energy and the potential of energy crops for Irish farmers.
www.teagasc.ie/events
barry.caslin@teagasc.ie

March
12-13 *Tullamore Court Hotel, Tullamore, Co. Offaly*

Agricultural Research Forum 2007

This forum provides an opportunity for the presentation and publication of new scientific information relating to agricultural science (including animal and crop science, molecular biology and biotechnology), environmental and soil science, food science, agri-economics and forestry.
www.agresearchforum.com
michael.diskin@teagasc.ie

April
11 *Radisson SAS Hotel and Spa, Cork*

International Symposium on Advances in Milking

This symposium highlights the latest research, innovation, standards and developments relating to milking equipment. The intended audience comprises: manufacturers and distributors of milking machines; technicians involved in installation and testing of milking machines; personnel involved in advising farmers on milk quality and labour efficiency; advisors and consultants to the farming sector; and food inspection and control authorities. The event is jointly organised by Teagasc and the International Dairy Federation.
www.idf-milking.org
info@idf-milking.org

July
15-20 University College Cork

16th International Farm Management Congress

This congress will be of interest to all involved and interested in agriculture and broader rural development initiatives. Many of the topics covered will be of interest to farmers, farm managers, farming organisations and researchers, and will have particular relevance to government and state development agencies.
www.ifma16.org
General information: contact@ifma16.org
Paper submission: ifma16@ucc.ie

August
26-29 *University College Dublin, Belfield*

EAAP 2007

58th annual meeting of the European Association for Animal Production. This meeting will be of interest to those working on animal breeding production and management issues.
www.eeap2007.ie
eeap2007@ovation.ie

September
12-14 *University College Cork*

First International Symposium on Gluten-Free Cereal Products and Beverages

Coeliac disease is one of the most common lifelong disorders in the western world. It is a condition in which an individual's body reacts badly to the protein fraction of gluten or related proteins. This is the first symposium to be held on this topic.
www.glutenfreecork2007.com
fitu@ucc.ie

September/October
29.09-4.10 *The Burlington Hotel, Dublin*

2007 International Dairy Federation World Dairy Summit

'Dairying – can it manage change?' is a relevant theme in the light of the competitive pressures being felt internationally and the technological initiatives considered necessary to create added value opportunities based on milk. Symposia will cover areas of: global trade; marketing; dairy science and technology; nutrition and health; farm management; and functional foods issues. The increasing importance of 'food and health' will be covered extensively in the 'Nutrition' and 'Functional Foods' symposia.
www.wds2007.com
phil.kelly@teagasc.ie
Updates: info@wds2007.com

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