

T Research

Research and innovation news at Teagasc



Putting a value on access to farmland

Interview: Professor Patrick Cunningham

Managing mastitis more effectively

New dimensions in cereal research

Reversing the decline of farmland birds

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A quiet revolution

A quiet revolution is taking place in Irish science. Funding for R&D has greatly increased, more ambitious scientific targets are being set, new methodologies are being used for the allocation of research funds and entirely new models are being introduced for management of research programmes. Programme funding is assuming greater importance relative to project funding, and funding agencies are more proactive in target setting and output measurement. This is a very dynamic time for public scientists and one that raises new challenges both for the scientists themselves and for their institutional employers. Teagasc's Food Research Directorate is at the hub of these developments. External income from competitive programmes has greatly expanded and now accounts for half of the Directorate's €25m budget. Both the Moorepark and Ashtown Centres are partners in major collaborations, of which The Alimentary Pharmabiotics Centre (An SFI Centre for Science, Engineering and Technology) is a prominent example. Both are playing a prominent role in competing for recent research initiatives, such as The Enterprise Ireland National Functional Foods Research Centre. Teagasc's own 'vision' research programme is funding a major expansion of research, involving new core staff and construction of laboratories and research facilities to embrace new research in nutraceuticals and bioactives for obesity and gut health. The Food Directorate's management system, which emphasises both scientific quality and innovation impact, must adjust to the new types of relationships with collaborators and funding agencies that accompany these developments. Teagasc has a special mandate for technology transfer to industry and, in the right structure, can be a productive partner for academia in establishing industry links while, at the same time, drawing on academia to enhance the scientific depth of its research. These developments have not gone unnoticed abroad, where there is increasing admiration for the focus and synergy that we are now bringing to national food research. This is significant, because the ultimate test for Irish research is how we measure up to the best elsewhere and how we contribute to the international competitiveness of our industry.



WJ Donnelly
Director of Food Research
Teagasc



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Potato breeder Denis Griffin at the Oak Park Open Day.

Oak Park Crops Open Day

Teagasc Oak Park's Open Day featured the full spectrum of crops research from organic farming to the latest and most innovative uses of biotechnology in agriculture.

Some of the most exciting developments from the Crops Research Centre include the two new potato varieties, Setanta and Orla, which are extremely suitable for production on organic farms. These are just two of eight new varieties that have been bred at Oak Park and released for commercial production on farms in the last five years. Both Setanta and Orla have higher levels of resistance to potato blight and storage diseases. Teagasc has a long tradition in plant breeding, with the hugely successful and well-known variety Rooster, which was also developed and bred in Oak Park. Alternative land use is now a major topic of discussion worldwide and the excise relief scheme announced by the Government is creating huge interest in this area. The Open Day outlined the opportunities to grow energy crops, such as willow, miscanthus, grain and oilseed rape, and the commercial prospects for using land for non-food purposes. Teagasc researcher Bernard Rice highlighted the potential for Irish farmers to supply this emerging market and what farmers should consider before embarking on major investment in this area.

New Teagasc Authority member



Margaret Sweeney has been appointed to the Teagasc Authority for a five-year term by the Minister for Agriculture, Fisheries and Food, Mary Coughlan, TD. She fills the seat vacated by Anna May McHugh, National Ploughing Association, who has completed a five-year term on the Authority.

Margaret Sweeney is Chief Executive of Postbank, the community-based bank. Margaret previously ran her own business consultancy company and was formerly chief executive of Aer Rianta and a director with KPMG. A native of Donegal, Margaret is a Fellow of the Institute of Chartered Accountants in Ireland and has a Bachelor of Commerce degree from the National University of Ireland Galway.

SCAR foresight conference

By ensuring that the right questions are asked, scenarios are important in assisting agriculture to cope with a range of complex and interlinked challenges, such as rapidly increasing globalisation, climate change and unsustainable consumption of natural resources. In that perspective, the SCAR (the EU Standing Committee on Agriculture Research) launched a foresight process in 2006 aimed at identifying possible scenarios for European agriculture in a 20-year perspective, to be used in the identification of priority research needs for the medium and long term.

An expert group was appointed to synthesise the existing analytical and foresight material in relation to eight "major driving forces" for agriculture in Europe. The group has issued a foresight paper on each area:

- climate change;
- environment;
- economy and trade;
- energy;
- societal changes;
- health;
- rural economy; and,
- science and technology.

The analysis of these major driving forces and their possible interactions led to the identification of four futures scenarios – climate shock, energy crisis, food crisis and cooperation with nature.

The scenarios flowing out of the above process will be used, both at European and national level, to define better policies and to build a medium- to long-term research

agenda for European agriculture that is robust and evidence based. The views expressed and conclusions drawn were used, along with other stakeholder consultation, in preparing input for the conference on 'Towards Future Challenges of Agricultural Research in Europe', which was held in Brussels on June 26-27, with wide participation from scientists (agriculture and foresight) and policymakers. In particular, the conference highlighted the critical importance of climate change as a driving force in agriculture up to 2020, and the importance of putting in place both adaptation and mitigation strategies. The conference also emphasised the growing importance of competitiveness in EU agri-food, as it faces the long-term future, and the need to focus on the development of the knowledge-based bio-economy. This is an economy increasingly based on biological solutions enabled in general by advances in science and technology and, in particular, by advances and investments in the life sciences. While the creation of new knowledge, through investment in research, is vital to the full realisation of the bio-economy, the establishment of structures for the transfer of knowledge is also important. In this regard, considerable emphasis was placed on the development of extension services, which would empower the farmers and rural dwellers of the future to access new information and technology.

RERC student day winners

John Cullinan was the winner of the Bob O'Connor Prize for a study on environmental value transfer in the Agricultural Economics Society of Ireland (AESI) annual student competition for 2007. Darragh Clancy received a prize for the best first-year presentation for his work to date on the economics of bioenergy. Both students are attached to NUIG. The Rural Economy Research Centre (RERC) hosted the event, with presentations from 15 PhD students covering topics including farm efficiency, bioenergy, environmental goods and healthcare in rural areas. This year's competition was judged by AESI President Seamus O'Reilly of UCC and former RERC staff member, Brendan Riordan. "The success of the annual student day is highlighted by the number of participants involved, reflecting the fact that the event continues to provide valuable experience for students," noted Trevor Donnellan, RERC, who organised the event with Thia Hennessy, RERC. "It is no surprise that a number of RERC's newer staff have first come to prominence through the competition and this year the quality of the presentations was exceptional," he said.



Pictured at the RERC student day are (from left): Cathal O'Donoghue, Head, RERC; Seamus O'Reilly, President, AESI; John Cullinan, Bob O'Connor Prize winner 2007; Darragh Clancy, Best First Year Presentation 2007; and Brendan Riordan (formerly RERC).

To mark the tenth anniversary of Bob O'Connor's death, the event included an appreciation of his life by Brendan Riordan. Student presentations from the day can be downloaded at www.tnet.teagasc.ie/rerc.

Animal Biosciences Centre

The Teagasc Authority has approved the establishment of a new Animal Biosciences Centre at Grange, Co. Meath. It is expected that work on the building of the Centre will commence in early 2008 and completion is planned for March 2009. The position of Head of Centre will be advertised shortly.

Teagasc invests for the future

Teagasc is embarking on an ambitious capital investment and staff resourcing plan. Addressing the 16th International Farm Management Congress, acting director Tom Kirley said: "Centres of excellence in animal science, crop science, environment and land use, rural research and food for health, are currently being established. A very significant capital investment programme costing €27 million is being undertaken together with the recruitment of additional research staff. The programmes seek to harvest advances made possible by developments in science – and in the biosciences in particular – for the benefit of Irish agriculture and Irish society generally."

Young Horticulturist of the Year

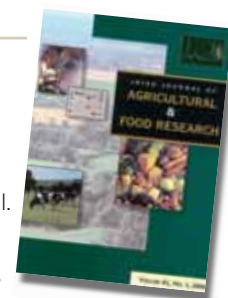
Jimmy O'Connor, a first-year BSc in horticulture student at the Salesian College of Horticulture, Warrenstown, Co. Meath, has won the Young Horticulturist of the Year Competition 2007. The competition is organised annually by the Institute of Horticulture and brings together the winners of the eight regional finals throughout Ireland, England, Scotland and Wales. Jimmy received a cheque for £2,000 sterling (approx. €2,900) from the Percy Thrower Trust, to be used to travel to a location of his choosing to undertake research into plants and horticulture. Jimmy completed a FETAC certificate in horticulture last year at Warrenstown College, receiving a distinction. He is currently studying for his first-year exams in the BSc course in horticulture, which is jointly offered by the Salesian College at Warrenstown and the Institute of Technology, Blanchardstown.

New food publication

The Institute of Food Science and Technology of Ireland has launched a new publication – *Food Science and Technology Ireland* (see: www.ifsti.com). The first issue features an article from a joint Teagasc Ashtown Food Research Centre–Dublin Institute of Technology innovation project.

IJAFR online

Teagasc's peer reviewed publication, the *Irish Journal of Agricultural and Food Research*, is now fully online in PDF format and can be viewed at www.teagasc.ie/research/journal. Archive issues will also be placed online on a phased basis.



EAAP conference

The theme of the Annual European Association for Animal Production Conference taking place in Dublin this August is 'Sustainable animal production – meeting the challenges for quality food'. This is highly appropriate given the changing environment in which the agri-food sector operates and in view of the valuable contribution the sector makes to national economies.

A number of satellite symposia and workshops will take place during the conference, including the annual Interbull (International Bull Evaluation Service) meeting and the 13th Workshop for European National Co-ordinators for the Management of Farm Animal Genetic Resources. The conference has been jointly organised by Teagasc, the Department of Agriculture, Fisheries and Food, the Irish Grassland Association, the Irish Business and Employers Confederation, the Irish Cattle Breeding Federation and University College Dublin. For more information, see www.eaap2007.ie.

Bioenergy 2007

At the launch of 'Bioenergy 2007 – Fuelling Ireland's Future', which will take place at Teagasc Oak Park on August 30, are: Mary Wallace, TD, Minister of State at the Department for Agriculture, Fisheries and Food with responsibility for Forestry, along with, from left, Sustainable Energy Ireland's David Taylor, COFORD's Eugene Hendrick and Teagasc's Acting Director, Tom Kirley.



International nitrogen workshop

Two Walsh Fellows (Alina Premrov, Trinity College Dublin and Samuel Dennis, Lincoln University, New Zealand) based at Teagasc Johnstown Castle, recently attended the 15th International Nitrogen Workshop in Spain. With the Nitrates Directive now in force, researchers are looking at tools for the implementation of the Directive to ensure the development of viable and sustainable agricultural systems.

Bernhard Osterburg, Federal Agricultural Research Centre (FAL), Germany, presented a results-oriented approach to farm subsidy payments for N-efficiency improvements, as an alternative to the current means-oriented approach. In this system, which was developed for Germany, farmers would be free to choose how they wished to lower nitrogen losses from their farm, and to design a suitable farming system for themselves, rather than simply conforming to legislated stocking rate and fertiliser targets. They would then be rewarded for actual reductions in nitrogen losses, as calculated using a farm-gate N balance. This would make farmers actively involved as entrepreneurs, and put them back in charge of their own farming system. Several difficulties with this approach were outlined and solutions presented.

WDS 2007

Ireland, as a national committee member of the International Dairy Federation (IDF), will host the World Dairy Summit 2007 (WDS 2007) in Dublin from September 29 to October 4, 2007, which will attract 600 to 800 international delegates.

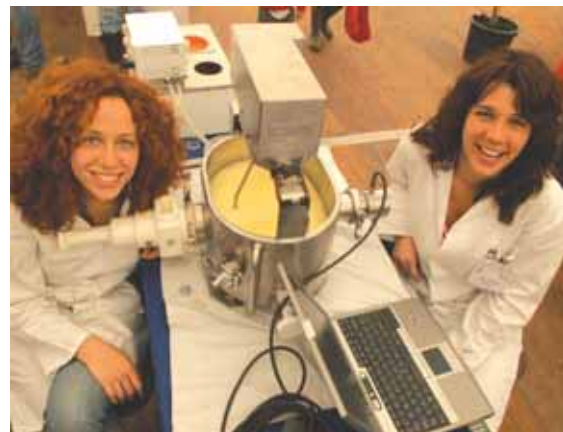
Many feared the impact that recent EU subsidy cutbacks would have on Ireland's ability to compete in international dairy export markets yet, in the current year, a number of global events have combined to create demand for dairy commodities that is outstripping supply. As a result, the industry is turning to dairy economists and other such experts for guidance on future market predictions. These issues will be addressed at both the 'Dairy Leaders Forum' and the 'Dairy Policy and Economics Symposium', where dairying in a post-EU milk quota regime will be examined.

Moorepark Open Day



Huge crowds braved the weather to attend Moorepark 2007.

Over 10,000 visitors attended the Moorepark Open Day in Fermoy, Co Cork. The latest science and technology to assist dairy farmers, along with the most innovative dairy food research being undertaken by Teagasc, was presented at the event.



Pictured at the Moorepark Open Day are Clara Talens (UCD) and Walsh Fellow Maria Mateo, both from Spain, who are carrying out research in the Food Processing and Functionality Department at Moorepark Food Research Centre.

Other symposia include: Dairy Science and Technology; Functional Foods; Milk Production and Farm Management; Marketing and Nutrimarketing; Nutrition and Health; Dairy Research and Development; Current Research and Development in Future Technologies; and Environmental and Food Quality.

The Secretariat thanks the Irish Dairy Board (IDB), ICOS, IBEC/IDIA, the National Dairy Council, the Department of Agriculture, Fisheries and Food, and Teagasc. Sponsors include: IDB; Bord Bia; AIB Bank; the Department of Agriculture, Fisheries and Food; Glanbia, Kerry Foods; and Enterprise Ireland. Teagasc staff involved in the organisation of the event are: Professor Liam Donnelly, (Dairy R&D); Dr Catherine Stanton (Nutrition and Health); Drs Pat Dillon and Padraig French (Milk Production and Farm Management); Dr Phil Kelly (Functional Foods Forum and Secretary of the Organising Committee); and Trevor Donnellan (Dairy Policy and Economics).

First among equals

Professor Patrick Cunningham began his career with An Foras Talúntais. He now holds the position of Chief Scientific Adviser to the Government, but still takes a great interest in his roots in agriculture, as he relays to CATRIONA BOYLE.

When Professor Patrick (known to most as Paddy) Cunningham started his career with An Foras Talúntais (AFT – now Teagasc) in 1962 there was no way of knowing the heights he would reach.

"When you start a career you don't have long-term ambitions. Your horizon is generally a few years ahead. In those days there was a spirit of working for the nation, and the founding Director, Dr Tom Walsh, had that kind of economic patriotism that carried through to the staff. It was easy enough to see the reality of that because the farming industry was very interested, as most of the research was practical and helped the lives of progressive farmers."

Paddy became Department Head at AFT in 1970 and Deputy Director (Research) in 1980. His work at AFT focused mainly on genetic improvement in the Irish cattle population.

Chief Scientific Adviser

The job of Chief Scientific Adviser is to provide advice on scientific issues of concern to Government across the spectrum of disciplines, and to provide scientific input to the development and review of the Government's Strategy for Science, Technology and Innovation (SSTI 2006-2013). The Chief Scientific Adviser reports, via the Interdepartmental Committee on STI, to the Cabinet Sub-Committee on STI.

There is no doubt that Paddy Cunningham is well qualified for the job. His reputation has been built over a long and varied career, including stints with the World Bank, as visiting Professor at the Economic Development Institute in Washington and as Director of Animal Production and Health at the Food and Agricultural Organisation (FAO) of the UN in Rome. Paddy started lecturing in Trinity College Dublin around the same time that he joined AFT. In 1974 he was appointed Professor of Animal Genetics there and that is where he has spent the most recent part of his career.

His pioneering programme of animal genetics research led to the development of a biotechnology company, IdentiGEN, which developed a system of DNA traceability for the beef industry following the BSE crisis.

Biofuels

Teagasc's biofuel research programme began during the last energy crisis in the 1970s. The programme has continued since then, but rising oil prices and scarcity have created a renewed interest in biofuels.

Paddy believes we could double our tillage acreage to grow crops for energy without hurting the volume of grass produced.

"You can never drive down the production cost of a crop to the level of a product that you simply pump out of the ground. As long as oil is in plentiful

Settling in

To date, Paddy has been spending time talking and listening to the science and technology community here in Ireland and building relationships in other countries. He says it is important that we have an open network, not just for crisis resolution, but so that we are aware of what studies and analyses are being done.

"I've been building my network of contacts to provide access to the very best advice to the Government on issues not just as they arise, but even over the horizon, such as the current energy and fuels debate. But I don't stand alone because, on any issue, for example, avian flu or foot-and-mouth disease, you already have people who are more expert than I am in any particular area. My first task would be to consult with experts here in this country and make sure that I have an independent view on the advice that they're producing."

Genetic improvement through AI

Much of Paddy's early research was based on cattle breeding and making the most of genetic change that could be delivered through an artificial insemination (AI) service.

"One of the limitations in Ireland has always been our seasonal production system because it made sense for dairy farmers to use AI for the early part of the season and then turn a bull in for the remainder. And even more so in the beef herd, the suckler cows, which is now half our cow population, and is generally managed by part-time people who haven't got the time to operate AI.

"There are very good operational reasons why AI is lower in this country than it is in countries with different production systems. Against that, you can show that properly tested and selected AI bulls can give you levels of genetic improvement that you cannot get with a natural service bull because that's very much a lottery. "For the farmer it's a trade-off between the extra time, trouble and money required to use AI as against the prospect of this genetic improvement. For some, particularly at the high end of the business, they reckon the genetic improvement is worth it. But they also tend to be the better organised and the bigger enterprises. "That balance of advantage and disadvantage will continue, but there is a

supply, it will always be able to undercut a crop-derived road fuel, so we're depending on oil becoming scarce and dear. Then the value of road fuel that is grown in a field of rapeseed meets a rising market. With oil available at \$60 a barrel, it's getting close to feasible.

"Now, we don't know where that is all going to settle out yet because we don't know the full production cost – that's production, processing and delivery of road fuels – so that's where the research is needed, to improve the efficiency of production by increasing output per unit of input. After that it's a question of what you do with taxation of the fuel."



concern that with growing herd size and additional pressures on management and labour in our short breeding season, one could expect a drop in the business, and we've seen that in recent years. That's a matter of concern, because we're obviously not improving the genetic capacity of the herd as fast as is possible."

Teagasc's role

Teagasc's role in Irish agriculture has changed somewhat since Paddy's time there. "It's serving a different industry now than it did several decades ago. On the one hand, there are professional full-time farmers who are more demanding and more appreciative of technical efficiency than ever. But, for many other clients, there are

wider questions of rural development, livelihoods, welfare, farmers' markets, the environment and organic production; all of which are important to both people and to the nation. That's a more diffuse set of objectives, and one that's not as easily served by the kind of technical research that was done in the past. I can see that Teagasc has responded to that challenge with a good deal of energy.

"Then there is the relatively more important place that the two food centres have now in terms of adding value to our five million tonnes of milk and two million beef animals per year, which is the primary output of agriculture. Adding value is hugely important. "I see that the agricultural and food sector had €8bn of exports last year, which is a record. It's not as if we have a declining industry. It's still an industry with a

GM crops

Paddy believes that because the crops sector in Ireland is small, and because the main crops to which GM technology is applied (corn, soybean and cotton) are not grown in this country (though some corn is grown for silage), that the GM debate to date has been a largely academic issue for Ireland. "Its main application here was going to be in sugar beet but that's gone. There is a prospect now of blight-resistant potato and there are other things coming down the line that are quite exciting. The technology is now 10 years old and

over 100m hectares of GM crops are grown worldwide. The EU has funded over 80 projects on aspects of GM safety and concluded that the safety record is excellent. For many people the question of its impact on human health is not a significant issue anymore, though opinion surveys continue to show very high levels of public concern. As long as that concern persists across Europe there could be market advantages in being GM-free. However, there are costs and difficulties, including EU legislation, to be dealt with along that road, and it will take some time to sort out the balance of advantage and disadvantage for this country."



potential to expand. We have guaranteed access to 500 million of the world's best-financed consumers (the European Union). We're already significant contributors to that market pool and we should be able to grow that; however, the efficiency of the food industry is very important in delivering on that potential.

"Agriculture will, I think, for a generation or two into the future, continue to provide a much higher proportion of national economic welfare in Ireland than in any other country in Europe."

Building a knowledge economy

"We have to have a centre of expertise to lead the industry and Teagasc is it. Teagasc is the main national investment in this area. It has a good track record of delivery and it's now in the process of adapting itself to the new demands. Looking at it from the outside, I think it's going very well. It has the resources to do it because it's been very well supported by the government.

"The knowledge economy applies in agriculture as it does in everything else. It's an increasingly sophisticated and competitive market for the products of agriculture. If we stay producing just commodities we are competing with other low knowledge commodity suppliers of the basic raw materials and you are a price taker rather than a price maker. I'm saying the obvious here because

everybody recognises that, but still, it hasn't happened to the same degree as it has in some other countries. We have to climb that tree of knowledge and sophistication.

"Adding value doesn't necessarily always consist of adding new ingredients or more complex industrial transformation. It may be adding qualities that are of value to the end user, such as security, nutritional quality, guarantees of origin and branding."

Education

Paddy believes that the National Development Plan's (NDP) objective to double the number of PhD students is where much of the answer lies.

"The only way to stay ahead of that game is to grow in sophistication, which requires an investment in knowledge and the people who carry the knowledge. Not just to use existing knowledge, but to build on it, to develop it.

"The investment in science and technology in recent years has brought this country up to about average in the Organisation for Economic Cooperation and Development (OECD) ranking.

The knowledge economy applies in agriculture as it does in everything else. It's an increasingly sophisticated and competitive market for the products of agriculture.

"National expenditure on R&D is 1.56% of GNP and our declared intention is to get up into the top quartile, which will require bringing it up to between 2.5% and 3% of GNP. However, GNP will grow. In the last 10 years, the national spend on R&D has more or less kept pace with the outstanding growth in GNP. The declaration of the National Development Plan is that we will exceed the growth in the economy, that we will spend proportionally more, and that we will compete with countries higher up the OECD scale.

"While I think our education system is very good, we have been deficient in the fourth level, that is, the research and development level. We need to take people on from a basic degree into deeper knowledge, more professional competence, and in greater numbers.

"In the past it was mainly that there hasn't been the funding. The research grants are now available to a much greater degree than before and they are available on a competitive basis. The NDP has a very specific objective of doubling the number of people going on to PhD level. Can that guarantee to move Ireland up into the top quartile? I can't guarantee that it will because the opposition is moving too but it's a very good first instalment on transforming our education system into a highly research intensive system."

For more on the work of the Chief Scientific Adviser see www.chiefscientificadviser.ie.



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It is possible that bovine oligosaccharides can be fractionated from whey-based streams and used in infant and adult nutrition products as nutraceutical agents.

Milk's hidden gems

RAJ MEHRA describes a new research project to exploit the beneficial health properties of milk.

The role of milk in the first few days of life is to provide nutrition for the newborn's growth and development, and to protect against infection while the immune system is still immature. In addition to the main nutrients, such as proteins, fats, carbohydrates, vitamins and minerals, milk also contains oligosaccharides. Milk oligosaccharides are generally defined as carbohydrates composed of three to ten monosaccharide residues linked by glycosidic bonds. The building blocks of human oligosaccharides are mono-sugars, such as glucose, galactose, N-acetylglucosamine, fucose and sialic acid (N-acetylneuraminic acid). Human milk oligosaccharides have

been shown to: promote growth of beneficial intestinal flora in the colon and improve host gut health; provide defence against bacterial and viral infections; and stimulate the immune system.

A new research project to exploit the beneficial health properties of milk oligosaccharides was initiated with the support of Dairy Levy funding at the beginning of 2005 and additional support from FIRM in 2006. This is a significant development in strengthening Moorepark Food Research Centre's (MFRC) new programme focused on developing health-promoting components found in bovine milk.

Oligosaccharide composition of milk

Oligosaccharides form the third largest fraction of human milk after lactose and fat. Oligosaccharide concentrations range from 7-12g/l in human milk, and from 20-23g/l in human colostrum. On the other hand, bovine milk and colostrum contain only 30-60mg/l and about 200mg/l oligosaccharides, respectively. More than 150 different oligosaccharides have been isolated and characterised from human milk but only 18 have been reported from bovine milk. It is known that some of the oligosaccharides found in bovine milk are structurally and biochemically similar to those found in human milk. In addition to the free oligosaccharides present in bovine milk, some are also bound to proteins and lipids. One such protein, caseinomacropptide, is present in high concentrations (1.2-1.5g/l) in whey, resulting from manufacture of cheese or rennet casein.

Non-milk oligosaccharides

Other commercially available non-milk oligosaccharides include fructo-oligosaccharides (FOS) and galacto-oligosaccharides (GOS). The structures of these oligosaccharides are simpler than human milk oligosaccharides, and they are sometimes used to mimic the prebiotic effects of human milk oligosaccharides. Fructo-oligosaccharides are linear or branched fructose-polymers, and are extracted from vegetable plants. Galacto-oligosaccharides are galactose polymers, usually with a terminal glucose molecule, and are synthesised from lactose by enzymatic attachment of galactose molecules using β -galactosidase enzyme.

Biological function and health benefits of milk oligosaccharides

Prebiotic function enhances gut health

Milk oligosaccharides fit the definition of prebiotics as "non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon that can improve the host health". Milk oligosaccharides are neither digested nor absorbed in the upper intestinal tract of humans but are delivered intact into the colon, where they can act as fermentable substrates for lactobacilli and bifidobacteria, thus stimulating their growth. Breastfed babies have the advantage of ingesting higher concentrations of milk oligosaccharides because of the high levels of these carbohydrates in human milk compared to cow's milk and typical infant formulae. There are several studies of breastfed infants examining the effect of breastfeeding on the intestinal flora. Most studies demonstrate the development of an intestinal flora dominated by bifidobacteria and lactobacilli, most probably due to the oligosaccharide content of human milk.

Anti-adhesion effects and protection against infections

Another biological role of milk oligosaccharides is to provide protection against infection by pathogenic bacteria and viruses by acting as soluble competitive inhibitors for the binding sites on the mucosal epithelial surfaces of the intestine, an initial step of the infective processes. In addition, mounting evidence suggests that different human milk



MFRC researchers are working on developing novel oligosaccharide-enriched whey ingredients for adult functional beverages as prebiotic drinks.

oligosaccharides play important anti-infective roles in the intestinal, respiratory and urinary tracts against specific pathogenic bacteria and viruses, such as *Escherichia coli*, *Helicobacter jejuni*, *Helicobacter pylori*, *Shigella* strains, *Vibrio cholerae*, *Salmonella* species and *Haemophilus influenzae* or pneumococci.

Systemic circulation and immunomodulatory function

Excessive leukocyte infiltration causes severe tissue damage in a number of inflammatory diseases. The adhesion of leukocytes to the vascular endothelial cells and extravasation at the sites of inflammation is mediated by selectins (adhesion molecules). Since oligosaccharide ligands on leukocytes contain binding determinants for selectins, they influence the leukocyte rolling and adhesion to endothelial cells. It is suggested that some human oligosaccharides may act as anti-inflammatory components and support the lowering of inflammatory diseases in human milk-fed infants.

Role of sialic acids in brain development

Sialic acids play an important role in the early expression, brain growth and learning ability of breastfed infants. The highest concentration of sialic acid occurs in the brain as part of ganglioside structure. Ganglioside is a glycolipid composed of ceramide (fatty acid and sphingosine), glucose, galactose, N-acetylgalactosamine, N-acetylglucosamine and sialic acid. Human and bovine milks are rich sources of sialic acid found in the form of sialyllactose (formed from lactose and sialic acid), glycolipids and glycoproteins.

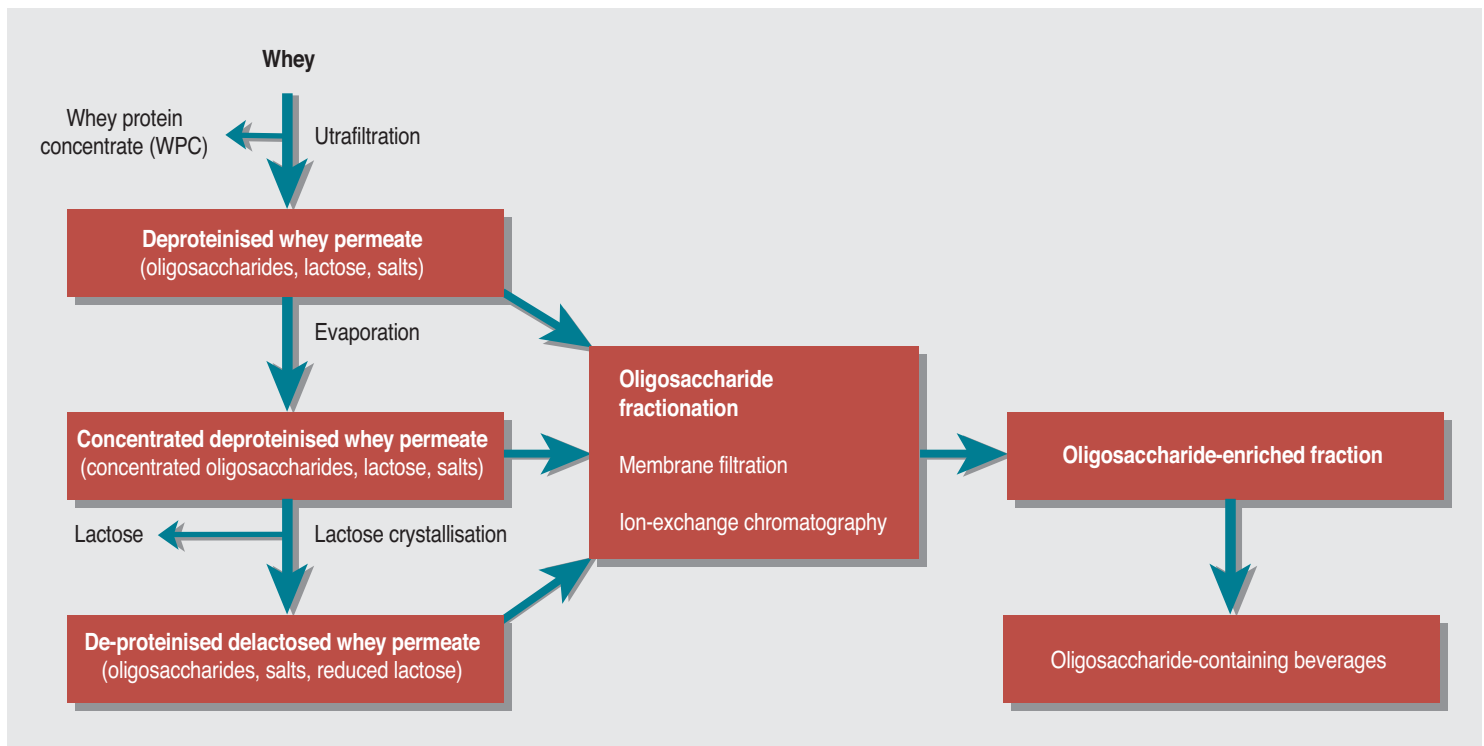


FIGURE 1: Fractionation and enrichment of oligosaccharides from bovine whey streams.

Milk oligosaccharide research at MFRC

The chemical structures of some of the bovine oligosaccharides are similar to those of human oligosaccharides. It is believed that bovine oligosaccharides of similar structures to human oligosaccharides may have some biological activity for protection of the infant against intestinal infection, thereby improving infant well-being. In this regard it is possible that bovine oligosaccharides can be fractionated from whey-based streams and used in infant and adult nutrition products as nutraceutical agents. However, there is little knowledge of the appropriate technologies and processes for fractionation and enrichment of specific oligosaccharides from whey-based streams, or on the relationship between the various structures of bovine oligosaccharides and their biological activities.

Milk oligosaccharides enhance gut health, stimulate immunity and improve our body defences.

The challenge facing the research team at MFRC is to develop novel oligosaccharide-enriched whey ingredients that can be used in infant and adult functional beverages as prebiotic agents to stimulate health-beneficial bacteria in the gut, and prevent pathogenic intestinal infections. Considerable new scientific skills and competencies in carbohydrate chemistry, fractionation technology for complex

carbohydrates, and analytical techniques for structural and biological activity characterisation of oligosaccharides have been put in place to address the challenges posed by this exciting area of research.

New separation technologies based on membrane filtration and/or ion exchange are being used at MFRC to isolate bovine oligosaccharides on the basis of size or ionic charge. Further knowledge of the relationship between structure and biological activity of bovine oligosaccharides is being investigated. This requires isolation and purification of these molecules in sufficient quantities to perform structural and biological activity determinations.

The specific tasks of the project include: development of a separation process for the fractionation and enrichment of oligosaccharides from whey; establishment of analytical methodologies for quantification and structural analysis of oligosaccharides; establishment and application of biological assays for evaluation of prebiotic and anti-infective activities of oligosaccharide-enriched fractions; and, development of beverages containing oligosaccharide-enriched whey fractions.



Dr Raj Mehra is a Principal Research Officer in the Food Cultures and Safety Department of Moorepark Food Research Centre.

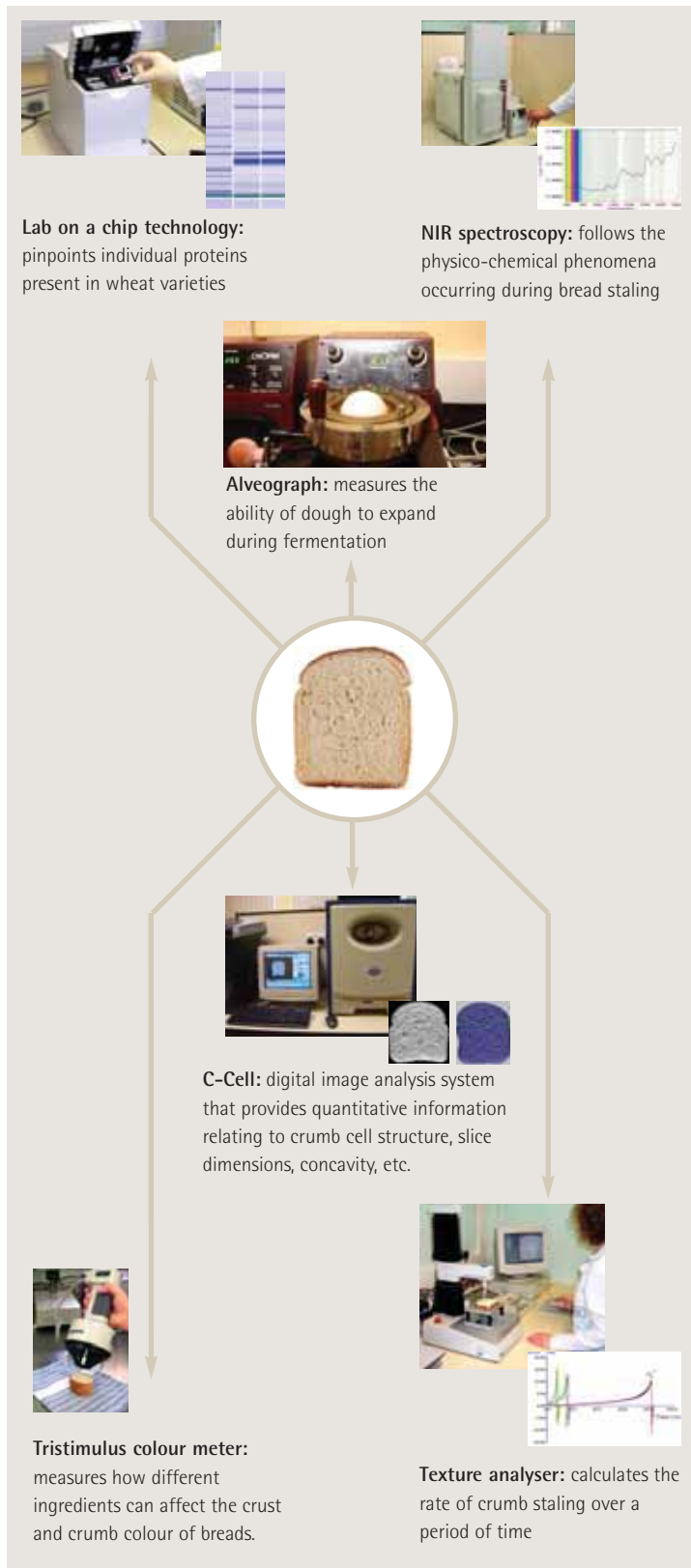


FIGURE 1: Some equipment used for cereal research at Ashtown.

New dimensions in cereal research

EIMEAR GALLAGHER describes research into improving gluten-free breads at Ashtown Food Research Centre.

Cereal research is a major component of the R&D programme of the Prepared Foods Department at Ashtown Food Research Centre (AFRC). Facilities at Ashtown include a mill room, test bakery, dough rheology laboratory and a sensory unit with eight computerised sensory booths. **Figure 1** shows some commonly used equipment for cereal research projects at Ashtown. Research in this area is undertaken with partners, including University College Cork, University College Dublin and Cork Institute of Technology. In recent years, cereal-based work undertaken at Ashtown has diversified into a range of novel and functional areas, some of which are discussed below.

Coeliac disease and gluten-free research

Coeliac disease is a life-long intolerance to the gliadin fraction of wheat and the prolamins of rye (secalins), barley (hordeins) and possibly oats (avidins). The reaction to gluten ingestion by sufferers of coeliac disease is inflammation of the small intestine, leading to the malabsorption of several important nutrients including iron, folic acid, calcium and fat-soluble vitamins. The disease is more common in Ireland than anywhere else in the world. It is particularly prevalent in the west of Ireland. Recent epidemiological studies show a significant increase in the incidence of



coeliac disease and gluten intolerances, mainly due to improved diagnostic procedures. The worldwide average of sufferers has been predicted to increase by a factor of ten over the next number of years, resulting in a growing market for gluten-free cereal-based products. Gluten-free bakery products can be regarded as 'double' functional foods. Firstly, they are 'inverse' functional foods in that a key constituent, i.e., gluten, is omitted. Secondly, they act as conventional functional foods as they are excellent carriers for healthy ingredients such as dietary fibre, prebiotics, available calcium and other constituents. Previously, research at Ashtown has focussed on including healthy ingredients in a basic gluten-free bread formulation. The use of inulin (which is a prebiotic dietary fibre) increased the fibre four-fold without influencing sensory or textural properties of the breads (Figure 2).

Formulation optimisation

Response surface methodology (RSM) is a statistical technique that has been successfully applied at Ashtown in the development and optimisation of cereal products. An optimised gluten-free rice bread formulation was developed using RSM, where optimum levels of hydroxypropylmethylcellulose (HPMC; a hydrocolloid) and water were determined (Figure 3).

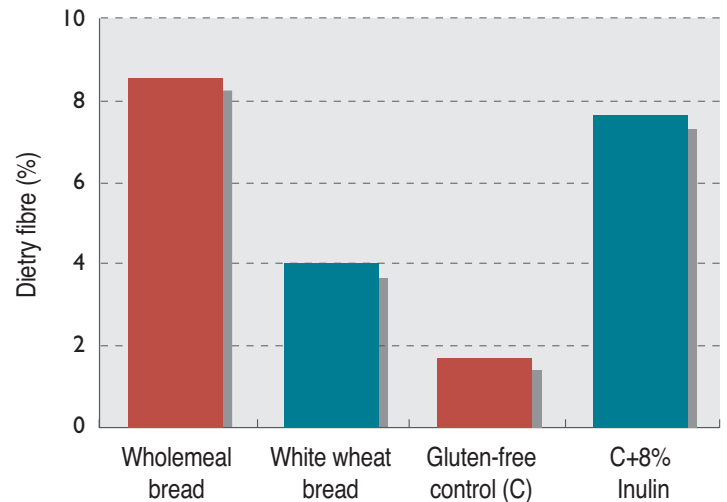


FIGURE 2: Dietary fibre contents of wholemeal and white wheat breads compared with gluten-free bread and gluten-free bread with added inulin.

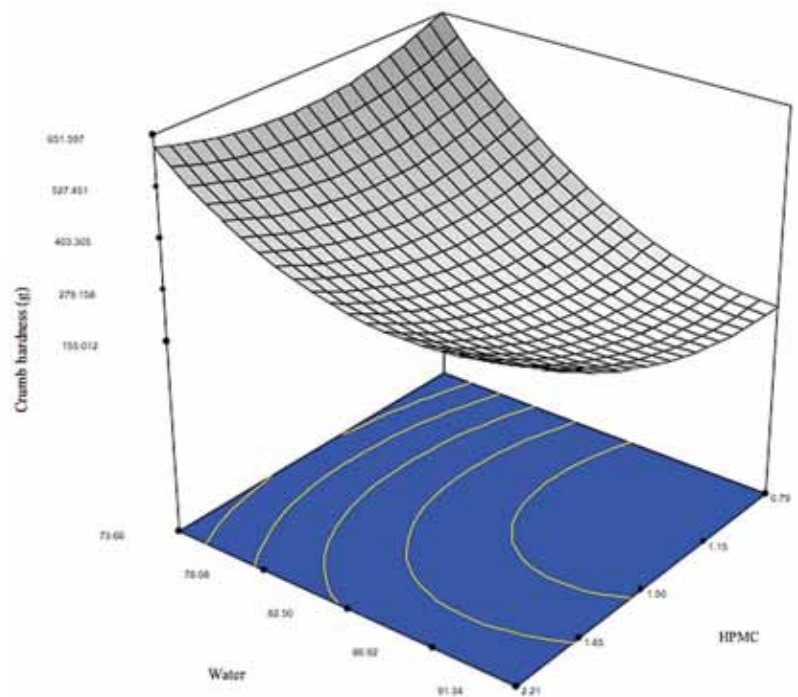


FIGURE 3: Effect of hydroxypropylmethylcellulose (HPMC) and water addition on crumb firmness of gluten-free breads made without wheat flour and with rice flour, potato starch and skim milk powder.

This figure shows that as the water addition in the bread formulation increases, crumb hardness decreases, i.e., the crumb becomes softer. At the same time, decreasing hydrocolloid (HPMC) levels in the formulation also results in a softer crumb. Mathematical software calculates the optimum levels of addition of these ingredients to produce the highest quality bread.

TABLE 1: Effects of pseudocereal inclusions on nutritive properties of gluten-free breads.

Bread type	Protein (%)	Fibre (%)	Calcium (mg/100g bread)	Magnesium (mg/100g bread)
Control (C; rice-based)	5.84	5.59	14.55	29.10
C + Buckwheat	7.72	9.91	19.00	23.74
C + Amaranth	7.96	9.97	18.72	46.79
C + Quinoa	7.36	10.82	39.01	48.77

Pseudocereal studies

Presently, studies are underway involving the application of pseudocereal flours in gluten-free bread formulations. Pseudocereals are plants that do not belong to the grass family but still produce fruits and seeds that may be used as flour for breads and other cereal products. Pseudocereals, such as buckwheat, amaranth and quinoa, have an excellent nutrient profile – they are rich in high quality protein, good fats, fibre, vitamins and minerals, and many have nutraceutical properties. They are also gluten-free and are now receiving much attention as functional ingredients. Initial studies have shown how the nutritive value of gluten-free breads may be enhanced by inclusion of such pseudocereal flours (Table 1). The antioxidant potential of these flours is currently being assessed. A novel approach is also underway, whereby near infrared (NIR) spectroscopy is being applied as an analytical tool to study the properties of the flours and the major macromolecular events that take place during dough proofing and bread staling. Proofing is the step in bread making between mixing and baking when the dough is allowed to rest in warm (about 35°C) moist (about 85% relative humidity) conditions. Yeast in the bread dough produces carbon dioxide, some of which is retained within the dough and some of which is lost. The dough piece expands and forms its final shape before baking.

The spectral information collected is being analysed using chemometric techniques, and results will then be related to the data obtained by reference methods such as baking tests, nutrient analysis, starch chemistry and flour protein fractionation. This will help the study of ingredient interactions, bread structure development and staling, as well as helping to identify critical proofing times.

Beta glucan studies in barley flour

The health-related importance of soluble fibre such as beta glucan has long been recognised. It has been shown that beta glucans have a positive effect on glycaemic insulin and cholesterol responses, as well as acting as soluble dietary fibre and as a prebiotic. Cereals (such as barley and oats) and seaweed are good sources of these functional ingredients. However, little is known about the process-induced effects (e.g., baking at high temperatures) on the bioactive compounds in these cereals. At AFRC, research has begun to assess the effects of fractionation (i.e., milling) and processing of barley flours on beta glucan levels, and on baking properties; the other partners in this project are focussing on the effects of beta glucans on gut microflora, colon histology, immune function, etc.

The milling process gives rise to cereal fractions such as endosperm flour, germ and bran. These are the starting materials for the production of cereal foods or are used for feeding purposes. Barley kernels are currently being fractionated, and the fractions obtained result from peeling and pearling the samples. With peeling, approximately 3% of the outermost layer of the kernel is taken off, and with pearling another 3.5% is removed. This work is being undertaken with the aid of the Bühler group (expert millers) in Switzerland. The remaining substance after the peeling and pearling is complete is milled into barley flour. A full compositional analysis of the fractions is being carried out and their processing ability studied, using bread as a model system. The effects of milling/fractionation and baking on beta glucan levels are also being tested.

The worldwide average of coeliac disease sufferers has been predicted to increase by a factor of ten over the next number of years, resulting in a growing market for gluten-free cereal-based products.

Attributes such as the gas-holding capacity of the resulting barley-containing doughs and dough development are being determined. The influence of the different fractions on loaf volume, texture profiles and the extent of staling during storage are under assessment. Future work will involve studying the impact of the various fractions on the dough matrix using laser, light and electron microscopy. Specific dyes that selectively visualise protein, carbohydrates, beta glucan, etc. will be used. Profiling of the functional ingredients and micronutrient bioavailability of the breads is underway. This project will serve to heighten the awareness of the nutritional aspects of alternative cereals to wheat, and optimise their inclusion levels and the processing methods in cereal products such as bread.

New approaches in wheat flour analysis

Each year, wheat varieties are received at Ashtown from field trials conducted by the Department of Agriculture, Fisheries and Food, and undergo routine testing. New fundamental research methods are now undertaken at all stages of this work programme, and the results will lead to maximising the utilisation of Irish-grown wheat in bakery products. In particular, attention is being focused on flour proteomics (i.e., assessing the different protein fractions within the flours) and the effects of mixing (e.g., electrical energy imparted on the dough during mixing) on dough and baking properties.

Flour proteomics

Gluten is the principal form (85%) of protein found in wheat, and consists of gliadin and glutenin fractions. Variations in grain protein content may significantly influence the dough properties of a wheat variety. Both quantity (percentage protein present) and quality (molecular size of the protein subunits) of the gluten proteins in wheat flour will determine its suitability for use in many products including breads, cakes and biscuits. At Ashtown, new proteomic studies using 'Lab-on-a-chip' technology on

wheat varieties are now underway. This method is based on traditional gel electrophoresis principles that have been transferred to a chip format. In brief, the proteins in the flour are initially broken down, isolated and denatured. The denatured solution is then loaded onto a bioanalyser chip and rapid electrophoresis takes place. The results provide accurate measurements of protein concentration and quality, where the proteins are separated according to their molecular weight. Results can be displayed as an electropherogram (where the different molecular weight polypeptides appear as peaks) or as a traditional electrophoresis gel (Figure 4). From the studies to date, it has been found that high-molecular-weight glutenin subunits (HMW-G), present between 65 and 150kDa, are the most significant indicators of high quality flours, suitable for bread making. Varieties with low-molecular-weight glutenin subunits (LMW-G) were less suitable for bread making and more appropriate for confectionery-type products. These results correlate with baking tests, where the HMW-G flours produced breads with high volume and good crumb grain characteristics. It is hoped that in the future, the bioanalyser alone will be a sufficient tool for assessing the potential end use for wheat flour samples.

Dough rheological studies

Mixing is a crucial operation during the bread making process. Apart from the successful blending of ingredients, mixing is responsible for the incorporation of air bubbles. These serve as nuclei for gas cells that will grow during fermentation and the early stages of baking, and also for the development of the gluten matrix, which leads to a smooth elastic dough that allows for gas retention (the ability of the dough to retain carbon dioxide gas and not collapse) during proofing and subsequent processing. These rheological properties of dough relate to the baking quality. To ensure proper dough development and the correct rheological properties, both mixing intensity and work input must be optimised. There are several ways to measure the rheological properties of doughs. Measurement of the biaxial extensional viscosity using uniaxial compression is one method. Large biaxial extension is the relevant deformation that takes place around a growing cell (gas bubble) during proofing, and is related (among other parameters) to the biaxial extensional viscosity of the dough. The importance of measuring this parameter is widely accepted. Tests are ongoing at AFRC to determine the effects of the type of mixer (using mixing speeds from 63 to 750rpm), and also the electrical input (from 80 to 350kJ/kg) during mixing on dough

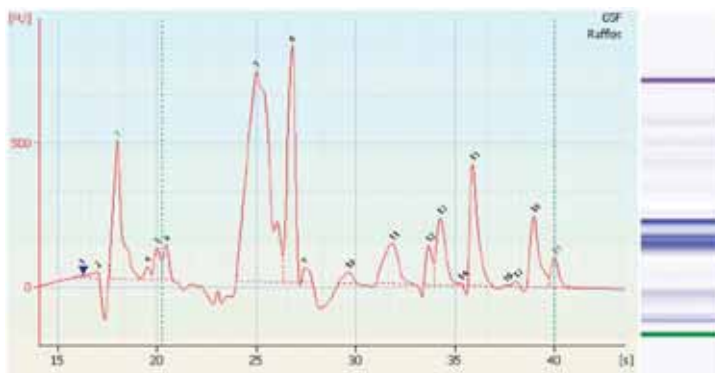


FIGURE 4: An electropherogram (left) and electrophoresis gel (right) showing protein subunits and their molecular weights.



rheology. This will lead to rheological tests that will predict the properties of the baked products. Tests performed on the mixed doughs are:

- uniaxial extension (where the dough is stretched in one direction);
- biaxial extension by uniaxial compression (uniaxial compression that forces the dough to extend in two perpendicular directions); and,
- monitoring the rate of carbon dioxide emission and retention in the dough during proofing.

Results from these tests are then correlated with baking tests such as loaf volume, crumb image analysis and crumb texture profile analysis. Bread doughs are required to have high extensibility and high maximum resistance to stretching in order to expand during proofing and retain gas for longer. Both of these properties were affected by the type of mixer used during bread processing. However, the bread properties (e.g., loaf volume) were only affected by the energy input and increased with increasing work inputs. Biaxial extensional viscosity results are a good indicator of the development of the dough and the ability of the dough to expand during fermentation. It has also been established that the biaxial extension test discriminates between the different wheat varieties in terms of strength and suitability for breadmaking. Results are also correlated with proteomic studies on the flours, using the method described in the previous section.

Functional potential

Cereal products are highly prominent in consumers' diets. As ingredients and processing technologies continue to improve, the need for cereal research remains. To enhance both the nutritional aspects and the manufacturing procedures of the products, information relating to the functional potential of ingredients, as well as their processing ability, needs to be studied.



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Putting a value on access to farmland

While the great majority of Irish landowners continue to facilitate recreational users, in recent times there has been an increase in the closure of lands. STEPHEN HYNES and CATHAL BUCKLEY are looking into the actual value of providing access for recreational activities.

There has been considerable debate in recent years on the issue of public access to farmland in Ireland and it is recognised that there are legitimate concerns for both landowners and users. The consumer-driven interest in the use of Irish farmland for recreation has prompted policy-makers and academic researchers to investigate the demand for rural recreation. It is accepted that rural recreation has the potential to generate significant tourism revenue in non-urban areas of marginal economic value and it is increasingly proposed as a vehicle for rural and regional development. Due to the increased interest in countryside recreation from both a consumer and policy-maker perspective, the Environmental Modelling Unit of the Rural Economy Research Centre (RERC) commenced a programme of research concerned with the valuation of recreational activity in rural Ireland in 2006. The valuation of hill-walking, recreational pursuits in forestry and white water kayaking were of particular interest, since they required in most cases access to (or across) privately-owned farmland.

Non-market public good valuation techniques

The valuation of recreation or environmental goods attempts to estimate the economic value, in monetary terms, which members of society receive from the use of natural resources. These resources cannot be efficiently allocated through markets due to their public good characteristics, such as being non-rival and non-excludable. Yet, walking in a farm forest or on upland commonage, or kayaking on a river, can provide an economic benefit to the individual even if a formal market does not exist to recognise this. It is a benefit for which the consumer would, if he/she had to, pay some monetary amount, perhaps a parking or access fee. The fact that they do not have to pay anything (in most cases) results in the recreationalist retaining a 'consumer surplus' as extra income.

Methods of valuing non-market goods (recreation or environment) are usually categorised into stated preference (SP) and revealed preference (RP) approaches. In the former, respondents are asked to directly state their



Walking in a farm forest or on upland commonage, or kayaking on a river, can provide an economic benefit to the individual even if a formal market does not exist to recognise this.

willingness to pay for recreational opportunities in the context of hypothetical changes in the supply or quantity of these opportunities. RP models are the main alternative to SP techniques for modelling recreation. The RP methods of valuation are based upon data drawn from observations of behaviour in real markets from which inferences may be drawn on the value of a related non-market good. Within the rural recreation project, the stated preference technique known as the 'contingent valuation method' is used to estimate the value of walking across lowland and upland farm commonage while the revealed preference method known as the 'travel cost method', which uses information on the distance individuals travel to carry out their recreational pursuits, is used to estimate the non-market value of white water kayaking and small-scale forestry recreation.

Countryside access in Ireland

All land in Ireland is owned either by private landowners or the Irish government (or a state agency). Recreational users do not have a legal right of entry to land in Ireland; access is at the discretion of the landowner. While the great majority of Irish landowners continue to facilitate recreational users, in recent times there has been an increase in the closure of lands. There are various reasons underlying this change in farmers' attitudes to recreational users on their lands. These include fear of litigation, poor behaviour by some recreational users, a decline in the economic viability of smaller farms and frustration that the farming community or

landowners are the one party not to gain any direct benefit from the commercialised recreational use of their land.

The valuation of hill-walking, recreational pursuits in forestry and white water kayaking were of particular interest in this research since, in most cases, they required access to (or across) privately owned farmland.

Government-supported initiatives to promote public access to the countryside in Ireland include The Irish Sports Council's 'National Waymarked Ways', the Slí na Sláinte walking routes under the auspices of The Irish Heart Foundation and forest walks run by Coillte (the state-owned forestry company). The National Waymarked Ways and Slí na Sláinte implement 'wayleave' agreements between landowners, local development committees and local authorities. Coillte also has an open forest policy, which encourages the use of forest walks. With a view to maximising the benefit of recreational activity to rural communities and providing a framework for the development of this sector, the Irish Department for Community, Rural and Gaeltacht Affairs established Comhairle na Tuaithe in January 2004.



Comhairle na Tuaithe is addressing three priority issues: access to the countryside; the development of a countryside code; and the development of a National Countryside Recreation Strategy. From a tourism perspective, guaranteed access to the Irish countryside by recreational users is imperative, as countryside pursuits are the bedrock of Ireland's special interests tourism plans. Within the special interests tourism category, walking tourism is Ireland's largest niche area, delivering the highest numbers of visitors.

Environmental valuation

Estimating the welfare effects of changes in the quality or supply of environmental goods is the main objective of most environmental valuation studies. Within the Rural Recreation Project, we therefore consider the implications for kayakers, forest users and walkers on farmland of changes in certain attributes of the forest, river or farmland. The results of the research show that a policy aimed at increasing by one unit the perception of water quality at the river Liffey would increase the welfare of kayakers by €1.89 per site visit. A policy of piping water for farm irrigation or the building of a small scale hydroelectric dam on one of the most popular white water kayaking rivers in the country, the river Roughty in Co. Kerry (the take out point on this river requires crossing privately-owned farmland to access the road) would reduce the water level by such an extent as to make it unnavigable by kayak. The water removal policy was found to reduce the

welfare of kayakers by an average of €9.61 per kayaker per trip. For the provision of a 'Waymarked Way' walk (with a formal landowner access agreement) through lowland farm commonage in Connemara, walkers were found to be willing to pay on average €9.13 per annum, while for the equivalent walk in upland areas walkers were willing to pay on average €5.69.

To maintain the farming landscape in the condition that outdoors enthusiasts expect when they visit the countryside for recreational pursuits, policy instruments will be required that integrate agricultural concerns with those of recreational demand on privately owned farmland.

Finally, for forestry users it was found that the investment in a wildlife viewing hide at a small scale forest site in Co. Galway would increase average walker visits from 4.5 to an estimated 9.18 per person per year. This corresponds to an increase in welfare of €36 per person per year. The creation of a sculpture garden at the same site resulted in an estimated increase in welfare per forest recreationalist of €29.53 per year.



What these results demonstrate is that recreational demand and accompanying economic values associated with the recreational use of the Irish countryside are significant. However, there is a linkage between recreational demand and a managed landscape provided by grazing livestock systems and managed woodlands, which underscores the importance of agricultural and rural development measures that support farming communities. To maintain the farming landscape in the condition that outdoors enthusiasts expect when they visit the countryside for recreational pursuits, policy instruments will be required that integrate agricultural concerns with those of recreational demand on privately-owned farmland, and that ensure the continuation of farming practices in areas of marginal land quality, the farmland type that is often the most valuable from a rural recreational perspective.

The debate will continue ...

Research by the Environmental Modelling Unit of RERC investigating the economic value associated with improved public access to farmland is generating considerable interest in the relevant economic and policy-making communities. Although policy-makers are aware of the economic opportunities associated with open-air outdoor recreation activities, rational public decision making on financing the improvement of public access requires that the economic benefits associated with rural recreation pursuits should be clearly identified and valued. Furthermore, the provision of any

new schemes for walking or rural recreation initiatives will depend on the supply of public funds, which must be justified to the public exchequer, the European Commission and the public at large. The results of RERC's programme of research in relation to rural recreation will inform this process. It will also, it is hoped, add considerably to the 'public access to the Irish countryside' debate.

Acknowledgements

The Rural Recreation Research programme of RERC has been part-funded by the Department of Agriculture, Fisheries and Food through the Research Stimulus Programme.

Dr Stephen Hynes is a Research Officer in the Rural Economy Research Centre, and heads up the Environmental Modelling Unit. His main areas of research are environmental economics and microsimulation modelling. **Cathal Buckley** has



recently joined RERC and is currently investigating attitudes and preferences of the general public and the farming community in relation to improved recreational access to farmland. E-mail: stephen.hynes@teagasc.ie.

Financial returns from organic cattle rearing

Organic farming continues to provide a rewarding income. BRIAN MORAN, National Farm Survey, outlines the results of the latest statistics from the joint Department of Agriculture and Food and Teagasc Organic Monitor Farm Project.

The market for organic food is growing strongly across all international markets, albeit from a low base. Food scares, combined with greater health awareness, have given rise to greater consumer demand for products that are produced in a natural environment. In Ireland, the growth in demand for organic food continues to outstrip domestic supply, resulting in imports of organic food to make up the deficit. The Department of Agriculture, Fisheries and Food oversees organic production in Ireland. It governs the sector based on what is set down in EU regulations on organic farming. There are 1,102 registered farmers in Ireland in 2007, farming 39,240ha, which represents 0.9% of total land farmed. Of the above, 25,768ha are fully organic and the remainder is in the process of conversion. The growth of organic farming in Ireland over the last decade can be seen in Table 1.

The data show that organic production grew rapidly in the 1990s, peaked in early 2000 at about 30,000ha and remained static until 2005 when there was further expansion to 1,104 growers farming almost 40,000ha. Organic production is located mainly in the west and the southwest, with counties Clare and Cork representing nearly 30% of producers. The proportion of



Organic suckler herd at Teagasc Johnstown Castle.

organic producers in the east of the country is significantly lower and, as a result, the area devoted to organic cereals and tillage is much lower than the national average. The majority of Irish organic farms are involved in drystock, namely, cattle or sheep farming. In a number of surveys of the sector, 65% of producers were involved with beef and a further 20% with sheep production. The majority of producers have more than one enterprise but the above percentages refer to the main enterprise on the farm. In 2007, there are 71 cereal producers farming 812ha and a further 246 horticulture producers with 355ha. Dairy farming is one of the least represented farming systems involved in organic production, due mainly to the lack of an organised organic milk processing sector.

Financial performance of organic cattle rearing farms

The data on organic farms were collected from farms participating in the joint Department of Agriculture and Food and Teagasc Organic Monitor Farm Project. In 2004, a steering committee on organic farming proposed the selection of a number of well developed and managed organic farms to be used as demonstration farms in encouraging and promoting new entrants to

TABLE 1: Irish organic farm numbers and area farmed 1995–2007.

Year	Farms	Organic area (ha)*
1995	300	6,400
2002	923	29,850
2005	978	35,260
2007	1,102	39,240

Source: Department of Agriculture, Fisheries and Food.
* Organic plus in conversion.

TABLE 2: Land use – organic versus conventional cattle rearing 2005 (ha).

	Organic	Conventional
Land farmed	31.3	27.3
Pasture	22.2	16.2
Hay	2.4	0.9
Silage	2.9	5.7
Tillage crops	2.3	1.1
Rough grazing	1.4	3.5

TABLE 3: Livestock units on organic and conventional cattle rearing farms – 2005.

	Organic	Conventional
Cattle	18.4	27.6
(of which suckler cows)	8.0	16.5
Sheep	1.9	1.3
Horses	0.3	0.2
Total	20.6	29.1

TABLE 4: Selected financial data for organic and conventional cattle rearing farms – 2005.

	Organic		Conventional	
	€/farm	€/ha	€/farm	€/ha
Gross output	25,471	823	28,784	1,054
(of which direct payments)	18,498	591	16,495	604
Direct costs	2,578	82	7,085	260
Gross margin	23,162	740	21,699	795
Overhead costs	6,564	210	8,970	329
Family farm income (FFI)	16,599	530	12,729	466

organic production. Data were analysed on the selected farms using the Teagasc National Farm Survey (NFS) farm recorders and recording and analysis system. Data on a sample of 11 organic cattle rearing farms were collected in 2005. It should be emphasised that the NFS farms were randomly selected by the CSO, while the organic farms were specially selected due to their level of performance and experience, and therefore would represent the more efficient sector of organic cattle production. Farm size and land usage are shown in **Table 2** for organic and conventional farms.

Organic farms were 14% larger than conventional, while grassland was the predominant crop, with 1.1ha tillage (mainly forage crops) on conventional farms compared to 2.3ha on organic farms. Conventional farms had 25% more of their area devoted to winter forage, with silage accounting for 86% of winter feed, while silage only contributed 55% to winter feed on organic farms, with hay providing the balance.

Livestock categories are shown for both systems in **Table 3**, with the organic farms having more sheep but 30% less livestock than conventional farms, despite having 14% more land. Combining land farmed in **Table 2** with livestock units in **Table 3** results in a stocking rate of 1.06 livestock units per hectare on conventional farms versus 0.66 on the organic farms. This is a key difference between both systems, with organic farms only achieving 62% of the stocking rate pertaining to conventional farms.

Conventional farms had higher output (28%) – both on a per farm and per hectare basis. 'Market' output, i.e., returns from animal sales excluding direct payments, was €12,289 per farm on conventional farms compared to €7,293 on the organic farms, which translates to €450/ha and €230/ha on conventional and organic farms, respectively. Total production costs (direct and overhead) were €16,055 per farm on conventional versus €9,142 per farm on organic, resulting in a family farm income (FFI) of €16,599 per farm on the organic farms versus €12,729 on the conventional farms. On a per hectare basis, FFI at €530 was 14% higher on organic farms than on conventional farms. The results shown in **Table 4** are similar, and confirm findings in a previous study carried out in 2001 on financial performance on organic drystock farms, which also found that organic drystock farmers achieved higher incomes than conventional farms due to lower production costs.¹ This is clearly evident in the data in **Table 4** where total costs form 56% of gross output on conventional farms compared to only 36% on the organic farms.

The dependence of the cattle rearing system of farming on subsidies and direct payments can be clearly seen in **Table 4** where they contribute 111% of farm income on the organic farms and 130% of farm income on

TABLE 5: Direct payments on organic and conventional cattle rearing farms – 2005.

	Organic		Conventional	
	€/farm	€/ha	€/farm	€/ha
Direct payments	18,498	591	16,495	604
(of which SFP)	6,259	200	7,223	265
REPS	5,947	190	2,125	78
DACAS	2,253	72	1,999	73

SFP = Single Farm Payment; REPS = Rural Environment Protection Scheme; DACAS = Disadvantaged Area Compensatory Allowance.

TABLE 6: Socio-economic data on organic and conventional cattle rearing farms – 2005.

	Organic	Conventional
Age farmer	51.8	54.0
Married (%)	72	64
Off-farm income (% holders/spouse)	71	61
Demographically viable (%)	60	57
Labour units	0.94	0.93

conventional farms, i.e., direct payments/subsidies account for more than 100% of farm income whenever market-based output is not sufficient to cover total production costs. The composition of direct payments is shown in **Table 5**, showing that the decoupled single farm payment (SFP) is the main contributor, followed by the REPS payment.

Organic farm households were demographically more viable than conventional farms – farm operators were younger, had a higher percentage of farm holders married and had more off-farm employment. In the Teagasc National Farm Survey, demographically viable is defined as the percentage of farm households that have at least one member under 45 years of age, and the survey data show that in 2005 60% and 57% of organic and conventional households, respectively, were demographically viable. Finally, the amount of farm labour used on both systems was almost identical at 0.94 and 0.93 labour units, respectively, on organic and conventional farms. FFI/ha on organic cattle rearing farms was 13.7% higher than on similar conventional farms, due entirely to lower costs of production (€292/ha vs. €589/ha). Output and direct payments per hectare were higher on conventional farms but not sufficient to cover the additional costs. Organic farms were 37% larger than conventional farms. Organic producers had a more viable socio-economic profile, while technical performance was higher on the conventional farms.

Reference

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Beef production in Ireland – facing up to the challenges



PAUL CROSSON describes a new research programme at Grange that aims to identify and describe systems of beef production that are technically, financially and labour efficient, to indicate the pros and cons of alternatives, to provide benchmarks for sustainable production and to analyse the implications of changes in the policy/market environment.

Beef farming in Ireland has been characterised in recent years by low family farm incomes and a considerable reliance on farm support payments to subsidise market-based margins. According to the Teagasc National Farm Survey in 2005, average family farm income on suckler beef farms was €12,730, with 130% of this derived from direct payments, i.e., without direct payments farmers would, on average, be making a net loss. While support payments were attached to production, market-based losses could be rationalised since the premia payments that were attached to production would cover these losses and return a profit to the farmer. However, since the mid-term review of the Common Agricultural Policy, farm support payments have been decoupled from production and thus systems of production must return a market-based net margin for farms to remain viable. A new research programme has commenced at Grange to identify and describe systems of beef production that are technically, financially and labour efficient, to indicate the pros and cons of

alternatives, to provide benchmarks for sustainable production and to analyse the implications of changes in the policy/market environment. The aim of this research programme is to provide farmers with the information they require to enable them to make informed decisions in relation to the systems of production that best suit their unique set of circumstances. Computerised models are being increasingly used in farm systems analysis to study production alternatives in a rapid, repeatable and consistent way. Two such models developed by Teagasc – the Teagasc Farm Systems Model and the Grange Beef Model – will be used to help meet the above objectives.

Production systems

Beef farmers in Ireland operate a multitude of production systems and regularly switch from one system to another due to continuously changing policy and market conditions. Nevertheless, profitability will invariably be driven by relatively high output and good production efficiency. High output

will be a function of high stocking rates, high weaning rates and good animal performance. Good production efficiency will depend on maximising weight gain from grass, judicious feeding of supplementary concentrates, operating an effective animal health and breeding policy, and maximising labour efficiency. The focus of this new research will be to investigate the implications of these and other factors on farm profitability, e.g., implications for profitability of increasing performance at grass. Bioeconomic simulation models such as the Teagasc Farm Systems Model will be used to investigate the impact of changing circumstances on farm technical and financial performance. The results will provide direction in terms of production systems and tangible financial incentives for farmers to improve efficiency.

Benchmarks

Farmers make decisions in relation to their farming systems based on their own unique set of farm and personal circumstances. These vary considerably from farm to farm. Many farmers are on marginal land and cannot achieve the number of grazing days or grass utilisation achievable by farmers on better quality land. In addition, as incomes from beef farming have decreased and labour costs increased in recent years, labour efficiency has become an increasingly important consideration. These are just two examples of the issues facing beef farmers when deciding between production alternatives. These alternatives will be investigated in detail, and pros and cons of the different approaches will be identified. Technical and financial benchmarks will provide farmers with attainable targets for profitable and sustainable production.

Future vision

To maintain profitability and hence viability, future systems of beef production will require increased output while controlling costs and meeting basic standards in relation to animal welfare, food safety and environmental sustainability. Ongoing research at Grange will provide the production technologies for future productivity gains. While, in the past, animal breeding technologies led to rapid advances in some production traits such as growth rate and carcass quality, genomic research has enabled the identification of trait-associated genes with the potential for significant advances in relation to more specific traits such as feed efficiency and disease resistance. The development of a new Animal Bioscience Centre at Grange will provide Teagasc with the capabilities to strategically identify and select those genes with the potential to provide the greatest benefits to the Irish beef sector. The aim of this research programme will be to evaluate the financial implications of these productivity gains at farm level and to provide a new set of targets for farmers.

On the feed supply side, there is a need for the development of a computerised program to evaluate the cost of home-produced feedstuffs for ruminants. The development of such a program will be an important outcome of this research. It will assess the impact of improved agronomic practices, new varieties, increased availability of purchased feeds and each farm's unique set of circumstances on the cost of providing feedstuffs to cattle. It is likely that grazed pasture will continue to be the cheapest feedstuff available to farmers and will therefore underpin technically and financially efficient systems of production. With regard to grassland

management, the focus continues to be on increasing production from grazed pasture by further refining grassland management, breeding and selection of improved varieties, and the integration of legumes in beef grazing systems. The economic implications of these new production technologies will be detailed, providing farmers with a vision for future systems of beef production.

Policy and market changes

While premia payments are no longer attached to production, these payments remain a significant source of revenue on beef farms and thus the criteria for receipt of these payments is very important for farm families. Current criteria include environmental, animal identification, public, animal and plant health, and animal welfare requirements. As these criteria change, systems of beef production that return the greatest returns may also change. The regulatory environment within which farmers operate is also subject to regular changes. For example, the Nitrates Directive imposed a maximum organic nitrogen limit of 170kg/ha on all farms. Furthermore, European and Irish beef farmers are becoming increasingly exposed to world markets as world trade liberalisation progresses. Any agreement of the WTO Doha round of negotiations is likely to have implications for export refunds and market access, further exposing Irish farmers. This continually changing environment requires an ongoing analysis of Irish beef systems to identify systems that maximise returns given the prevailing market and policy environment. Optimisation models, such as the Grange Beef Model, can be used to predict optimal systems given a range of such conditions. The Grange Beef Model is an optimisation model that identifies optimal beef production systems given a range of potential farm activities and constraints. An important objective of this research programme will be to further develop such models and to identify optimal systems given a range of differing conditions.

Facing the challenges

Irish beef farming is facing considerable challenges in the face of low beef prices, increasing production costs and an uncertain operating environment. This is all happening at a time when Ireland is experiencing an unprecedented economic boom, thus providing alternative employment opportunities for potential farm successors. However, there remains much reason for optimism. Global demand for beef is increasing at a rate greater than expected supply increases. Furthermore, societal expectations are increasingly toward food safety, environmental sustainability and animal welfare. European, and particularly Irish beef, is well placed to meet these expectations. The rise of biofuel production and the subsequent increase in food production costs should leave grassland-based systems of production, of the type operated in Ireland, at a relative advantage. The challenge is to provide a platform to remain profitable, given the immediate difficulties, and to ensure that future opportunities can be seized as they arise.



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Managing mastitis more effectively

Although farm management undoubtedly plays a major role in mastitis incidence and control, more effective therapeutics and disease-resistant genes are also required in the fight against mastitis. Researchers at Moorepark are looking at probiotics and the genes that confer mastitis resistance as a means of more effectively managing this disease.

Mastitis is a significant production disease on Irish dairy farms. It is an inflammatory response in mammary tissue caused by bacterial or fungal infections. Mastitis is diagnosed on presentation of swollen, hard quarters and clotted milk, in addition to an elevated somatic cell count (SCC). In Ireland, as elsewhere, it costs approximately €200 per cow per year. The cost includes antibiotic use, reduction in milk yield, milk wastage and premature culling. Following a pathogen invasion, somatic cells such as neutrophils flood to the site of infection to defend the cow against the attack. Somatic cells leak into the milk and their numbers in the milk are used as an indicator of a mastitis episode. The EU directive governing quality levels for bulk milk somatic cell count (BMSCC) dictates that BMSCC must have SCC of less than 400,000/ml. In line with this directive, Irish dairy co-ops have now introduced a bonus/penalty-based system where milk suppliers receive bonuses for milk with SCC lower than 200,000/ml and penalties for milk with SCC greater than 400,000/ml. However, in recent years, average herd SCCs have been on the rise in Ireland, indicating that the incidence of mastitis is also on the rise.

Although farm management undoubtedly plays a major role in mastitis incidence and control, more effective therapeutics are also required. The current method of mastitis treatment is two-fold: the antibiotic treatment of clinical mastitis cases as they occur during lactation; and the prophylactic or preventive use of antibiotics at drying off on all animals to prevent subclinical infections. Antibiotic treatment of clinical mastitis can be less than 40% effective. In particular, the low cure rate for *Staphylococcus*

aureus mastitis, a pathogen capable of hiding within epithelial cells of the host and therefore evading the host immune system, often leaves the farmer with no option but premature culling. The prophylactic use of antibiotics is also a cause for concern. The emergence of antibiotic-resistant strains, the growing demand for organic produce and public concern over the presence of antibiotics in the food chain have given rise to the need to investigate other methods of treatment. Any alternative methods developed must be cost-effective, easy to use and as much as possible of the treatment must be carried out by the farmers themselves. They must also represent an attractive option to consumers without causing further concern over the quality and safety of the food produce. This has led to the discovery of a number of potential therapeutics, including CD14, lysostaphin, bacteriophage and cytokine therapy. Moorepark Food Research Centre and Moorepark Dairy Production Research Centre, along with collaborators Professor Colin Hill from University College Cork and Professor Sean Arkins of the University of Limerick, are actively involved in research on mastitis treatment and prevention. At Moorepark, we are looking to probiotics as an alternative treatment.

Live culture treatment for mastitis

Probiotics are live bacteria that positively impact on the health of the host. Such health benefits include exclusion of harmful bacteria, stimulation of the immune system and gut microbial balance when taken orally. We have concentrated our research efforts on the application of probiotic bacteria –

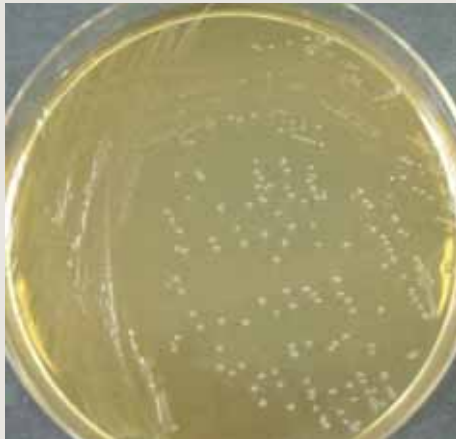


FIGURE 1: *Lactococcus lactis* on an agar plate. This organism produces the bacteriocin Lacticin 3147.

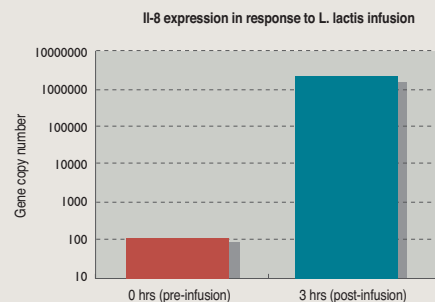


FIGURE 2: IL-8 'burst' after *Lactococcus lactis* infusion.



FIGURE 3: Holstein-Friesian vs. Norwegian Red – breeding for mastitis resistance.

and, in particular, bacteriocin-producing probiotics – to the udder for the treatment and prevention of mastitis. Bacteriocins are antimicrobial peptides produced by bacteria, which are capable of killing other bacteria. Lacticin 3147 is a bacteriocin produced by the non-harmful bacteria, *Lactococcus lactis*. It has a broad spectrum against all gram-positive bacteria, including many mastitis-causing pathogens. We have incorporated this bacteriocin into a teat seal and this has proven to be effective in preventing new infections in dry cows after exposure to the mastitis-causing pathogen, *Streptococcus dysgalactiae*. Lacticin 3147 also reduces *S. aureus* numbers in teats following a deliberate challenge.

Gene expression

More recently, we have looked at the friendly bacteria itself as a treatment for mastitis. *L. lactis*, when introduced into the teat canal, elicits a rapid local immune response in the cow. This includes an influx of neutrophils into the udder, essential to successfully fight a mastitis infection. The resulting inflammation is short lived and does not require any further treatment. In animal trials we have shown that *L. lactis* treatment is effective against gram-positive and gram-negative pathogens. Clinical cure rates with *L. lactis* have been found to be comparable to antibiotic treatment. To understand the mechanism of action, we have employed gene expression techniques. A gene is a segment of DNA involved in producing a protein. By measuring gene expression we can observe the bovine response, at the gene/protein level, to *L. lactis* infusion in the teat. We looked at the expression patterns of a number of key bovine immune genes in milk and blood. One gene in particular, bovine interleukin-8 (IL-8), has a massive response within three to eight hours of an *L. lactis* infusion. IL-8 protein is defined as a pro-inflammatory cytokine and is a powerful inducer of neutrophil migration. The magnitude of the IL-8 burst within hours of the *L. lactis* infusion culminates in an immune response that is rapid and pronounced. By measuring gene expression in blood, we have found that this stimulation is not systemic but is confined to the udder quarter. We believe that this local stimulation of the immune system by the friendly bacteria *L. lactis* supports the cow in its efforts to mount a successful rapid defence against a bacterial foe.

Although this work is very promising, further clinical trial work is needed to determine if probiotic administration is a successful alternative mastitis treatment inside the farm gate.

Cows resistant to mastitis

At Moorepark, we are also interested in why individual animals, and indeed breeds, differ in their mastitis susceptibility. More than 95% of the dairy cow population in Ireland at present is Holstein-Friesian. Over time, the Holstein-Friesian has been selected for its high milk yield. However, selection for high milk yield alone is generally accompanied by poorer health. To tackle this, our economic breeding index now incorporates health traits. It is hoped that such incorporation will help to select for animals with high milk yield and the capability to resist disease. Crossbreeding and alternative breeds can also offer us considerable merits in terms of health. For example, over the last 30 years the Norwegian breeding programme has incorporated selection in their Norwegian Red herd for improved mastitis resistance. As such, Norwegian Red animals are reported to be more mastitis-resistant than the Holstein-Friesian. Mastitis resistance/susceptibility in dairy cows is a complex trait, involving genetic factors as well as environmental influences. In the international research community, the quest to identify genes that have an effect on a cow's resistance/susceptibility to mastitis is well underway. These research initiatives include quantitative trait loci (QTL) data, where statistical tools, using data on an animal's genetic make-up and its mastitis/SCC history, map mastitis susceptibility to various chromosomes of the bovine genome. Once a location on a chromosome is identified, the DNA sequences of candidate genes mapped to that location are determined. Variation at the DNA sequence level in a gene can result in: (a) different production levels of the coded protein; (b) alteration in the function of the protein; or (c) the total inactivation of the gene. Such DNA variations are termed polymorphisms. For example, CXCR1, a chemokine receptor for IL-8, maps closely to a mastitis QTL on bovine chromosome 2. A polymorphism in this gene appears to decrease neutrophil migration to the site of infection. Animals with this variation are reported to have an increased incidence of subclinical mastitis. TLR4 is essential in the recognition of invading gram-negative bacteria.

Increased lactation persistency and decreased somatic cell score are associated with a polymorphism in TLR4. The aims of our study are to: identify polymorphisms in candidate genes for mastitis, determine if they are present in the Irish dairy population, and investigate a possible link with incidence of mastitis or SCC in the Irish context.

Breed differences in incidence

At the MFRC, gene expression analyses are also performed in parallel with genotyping studies to investigate how animals with different genotypes, and animals from different breeds, respond to invading udder pathogens. Animals from five different commercial breeds (Holstein-Friesian, Jersey, Normande, Montbéliard and Norwegian Red) are available for our genotyping endeavour. Although cow-to-cow variability is an issue, we can compare expression levels of immune genes from different breeds. This gives us an understanding at the molecular level of breed differences in the incidence of mastitis. Molecular knowledge, therefore, provides answers to phenotypic variations. This type of research work may help us to identify cows that, because of their genetic make-up, tend to be more resistant to mastitis pathogens and, therefore, may not need prophylactic antibiotic treatment. Genotyping can also fast track genetic improvement in breeding. We may be able to identify bulls genetically predisposed to sire daughters with low SCC and low incidence of mastitis.

Twin-track approach

In the immediate future the Irish dairy industry will need to: address increases in SCC; reduce dependence on antibiotics for mastitis treatment by the use of alternative treatments and/or alternative dairy (cross) breeds; and, limit prophylactic use of antibiotics for mastitis prevention. To support the industry in its efforts, the mastitis research team at Moorepark has taken a twin-track approach to understand the disease and to design new treatment strategies. This is a multidisciplinary team with expertise in microbiology, animal husbandry, immunology, gene expression, genotyping and quantitative genetics. The overall aims of this project, under 'disease' and 'therapy' pillars, are to: identify the main culprits of mastitis inside the Irish farm gate, evaluate live culture treatment, investigate the cellular and molecular response of different cattle breeds to pathogen assault, and use genetic predictors to identify cattle with inherent susceptibility/resistances.

This work was funded by the Irish Dairy Research Trust and the Irish Government under the National Development Plan 2000-2006.

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Elms in Ireland and their conservation

Dutch elm disease has devastated mature elm populations worldwide. GERRY DOUGLAS discusses Irish and European work to help conserve the mighty elm.

Elms were once to be found in every Irish townland and were as well known to people as ash or oak. Finding a mature elm today in Ireland is not easy. A healthy elm is something rare, to be valued as part of our genetic resources. Most trees were wiped out by a world pandemic of Dutch elm disease, which killed trees from the 1920s onwards. The killer is a fungus, *Ophiostoma novo-ulmi*, which is carried by flying beetles (*Scolytus spp.*) that like to eat elm leaves. As they chew the leaves they infect the wounds with the fungus, which then spreads throughout the tree causing it to die. Sometimes a tree may survive an attack by sealing off the invading fungus, but in most cases the tree will die over a period of one to three years. Dying trees are very attractive to mature beetles as a place to lay eggs under the tree's bark. The eggs eventually hatch into flying adults, which spread the fungus still further afield. When the fungus mutated to a more virulent strain in the 1970s, many millions of trees throughout Europe were killed and are still being killed every year. Efforts to save individual trees, such as cutting off affected branches, sometimes work but, generally, the pandemic has had a clear run.

Conservation of elm germplasm

Elm disease has been found in all counties and most populations of mature elm trees have been killed. A few mature individual trees remain in a healthy state in places such as Leitrim, Longford, Meath and Louth. Small groups of mature elms can be found in coastal counties such as Cork, Mayo, Donegal and Galway, as well as on Inis Mór. The individual trees that remain may carry a higher level of resistance to the disease and this may also be true for elms in coastal counties. In addition, the coastal elms may have been favoured by their climate of cooler temperatures and higher winds, since we know that the beetles need temperatures over 20°C for flying and headwinds may have reduced the frequency of visits by flying beetles into those counties.

Disease resistance

Efforts have been made throughout Europe to conserve remaining elms that may harbour some level of resistance to the current pandemic. It would not be surprising to find rare resistant trees as survivors among the many millions of infected trees. Hundreds of trees have been propagated and



FIGURE 1 (left): *Ulmus glabra*.

FIGURE 2 (right): A 175-year-old elm found in the graveyard at Castletownbere, Co. Cork.

planted into conservation collections *ex situ*. They have been assessed for resistance to different strains of the *Ophiostoma* fungus and different levels of resistance have been found among different individual trees by deliberately inoculating the trees with the live fungus. Nineteen trees out of 342 have shown 100% recovery from artificial inoculation; this indicates that those trees had a high level of natural resistance. You can find more information on this research at: www.biodiversityinternational.org/networks/euforgen/Networks/Scattered_Broadleaves/NHStrategies/UlmusSppConsStrategy.htm.

Conserving Irish elms

Teagasc's conservation project aims to locate, conserve and promote the planting of elms that are derived from remnant Irish trees. Conserved Irish trees may also be used in testing for resistance. With a view to sustaining viable populations of elms for the future that are adapted to Irish conditions, it is important to conserve those species for which sexual reproduction is a significant means of producing offspring. The main species in Ireland consist of *Ulmus glabra* (Wych elm, **Figure 1**) and *Ulmus minor*. There are many forms of *U. minor*, one of which is known as the Cornish elm. One such tree, estimated to be 175 years old, is located in the cemetery at Castletownbere in Cork (**Figure 2**). It is 4.5m in girth and 25m high. There are also many hybrid forms consisting of *U. glabra* with *U. minor*. Seed production by elms and natural regeneration of elm through seed is generally erratic. However, in 2006 we located a group of *Ulmus laevis* at Ardee, Co. Louth, with abundant seed that germinated to produce 15,000 saplings when grown at the Coillte nursery in Co Wicklow. Although *U. glabra* can set seeds in Ireland we have not found any stands with significant seed production so far. *U. minor* has a capacity for sexual reproduction but it is rare in northern countries. *U. minor* was once a widespread tree in Ireland in a form known as the English elm. It was valued for its straight stems and because it could be easily spread by transplanting young plants, which grow regularly from surface roots. The English elm has been examined recently at the gene level. This work revealed that the English elm of *U. minor* is a clone in which every tree is genetically identical to every other. Furthermore, it was shown to be genetically similar to trees in a specific region of Italy from which it was brought into northern Europe by the Romans as supporting posts for their



vineyards. Dutch elm disease rapidly killed mature English elms everywhere. Its root suckers replace the diseased tree and it survives throughout Ireland as small trees, which generally succumb to elm disease once they reach a height of about 20 feet.

Conservation collection

Our conservation work is concentrated on propagating mature trees vegetatively and on making a collection of as many mature elms as possible. The second stage is to establish them in the field as dedicated *ex situ* conservation collections. To maximise biodiversity within the elm collection, it is important that we have as many different genotypes as possible. So far, we have located over 80 mature elm trees in Ireland – all apparently healthy. Over the past two seasons we have investigated their propagation by cuttings taken at different times of the year from mid-summer to March, using over 3,000 cuttings. For cuttings collected in late summer we got some rooted cuttings from every tree; the rooting rate was 10-77% depending on the elm tree. Cuttings collected in March also rooted but at a lower frequency. These plants are now being grown to the sapling stage and will be returned to the owners. For longer term conservation of elms, it is appropriate and useful to grow the collected elms in the field and to maintain them in the form of hedges. Elm beetles are most attracted to trees over 1.5m in height, so trees in the form of hedges are safe from infection. We plan to establish such a conservation collection at an Irish arboretum, such as the National J.F. Kennedy arboretum at New Ross, Co Wexford. Since we have shown that elms can be propagated vegetatively, it is therefore feasible to produce elm trees by taking cuttings from the conservation hedges. In this way a supply of plants can be bulked up and used to establish new groves or avenues of elm. In addition, they could be re-introduced into multi-species plantations, as a component species for the Native Woodland Scheme, or in REPS schemes, where they would enhance biodiversity in both woodlands and hedges.



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Minimum tillage and its impact on field and soil invertebrates

Researchers at Oak Park are looking at the effect of minimum-tillage systems on field and soil invertebrates.

Conventional plough-based crop establishment systems invert the soil and cultivate it intensively to depths of 200mm and more. Minimum- (or conservation) tillage uses shallow (<100mm), non-inversion cultivation techniques for crop establishment. Research at Teagasc, Oak Park, has shown that minimum-tillage (min-till) systems of cultivation provide higher work rates, lower energy inputs, and lower machinery and labour costs than traditional plough-based systems. To date, crop yield potential has not been adversely affected by cultivation system. The effect of cultivation system on field and soil invertebrates, i.e., aphids, slugs, earthworms and beetles, is also being investigated. Initially, it was thought that the earlier sowing of crops in autumn by the min-till system could result in more widespread and serious epidemics of aphid-transmitted virus diseases of cereals, e.g., barley yellow dwarf virus (BYDV), and that plant debris and trash remaining on the soil surface of minimum-tilled land would lead to increased slug damage in emerging and establishing crops.

Aphid infestation and virus incidence

In the first season of investigation, significant findings were made on aphid infestation, and resulting virus infection, in autumn-sown barley. The aphid density in minimum-tilled barley during autumn was only half that of the conventional crop. The importance of this finding was highlighted in the following April when BYDV infection in the minimum-tilled crop was less than one-third of that recorded for the conventional-tilled crop. While aphid occurrence and virus incidence in the subsequent two seasons were considerably lower than that for the first season of the study, similar trends were recorded for both aphids and virus (i.e., reduced in min-till).

Straw incorporation

The incorporation of the previous crop's straw residue into the soil is increasingly carried out to reduce the depletion of soil organic matter in continuously cropped soils. Straw incorporation, using either method of cultivation, reduced the aphid infestation in autumn and the resulting virus



Ground beetle
(*Pterostichus melanarius*).

incidence. However, in the case of the conventional-tilled crop, the impact of straw incorporation, as might be expected, was less than that for the crop grown on minimum-tilled land. In one season, when both aphids and virus were widespread, straw incorporated in the minimum-tilled crop reduced aphid numbers to only one-third of that for the conventional-tilled crop, with a corresponding 55% reduction in virus. Further studies involving the application of straw to small-scale plots showed that winged aphid migrants in autumn did not infest crops to the same extent in straw-treated as in non-straw-treated land. Increasing the amount of straw applied to the soil inhibited aphids in landing on and colonising crops. Additionally, both min-till and straw incorporation resulted in significantly reduced rates of aphid population growth following crop colonisation. The latter effect is likely due, in part, to increased predation by natural enemies of aphids, such as ground beetles, whose activities are favoured by the presence of straw and its incorporation. One of the most interesting and, as yet unexplained, effects of min-till on aphids has been the finding of fewer aphids on the ears of wheat during early July when compared with wheat grown on conventionally-tilled land.

Slugs

Slug populations were expected to increase greatly in minimum-tilled relative to conventionally tilled crops and they did not disappoint. However, to date, damage to autumn-sown barley and wheat crops has not resulted in a depletion in plant density. The typical slug damage recorded has been the 'grazing' and 'shredding' of leaves, which is widespread in minimum-tilled crops. From three winter barley crops, followed by two crops of winter wheat, no finding of slug feeding on either seed germ or endosperm, or of the severing of plants either at or below the soil surface, has been recorded. Developing a better understanding of why increased slug numbers apparently do not lead to much greater levels of crop damage in min-till crops is a priority for future studies. Meanwhile, it appears from this research that there is no need to apply expensive molluscicides to control slug populations in



Winter wheat grown in conventional-till (left) and minimum-till (right) plots.



Minimum-till cultivator.



Seeder suitable for sowing into minimum-till ground.

min-till autumn-sown cereal crops. Some of these molluscicides are detrimental to non-target species such as earthworms and beetles.

Earthworms

These soil dwellers are known for their very significant contribution to soil fertility and structure by helping incorporate and break down organic matter, and by providing soil aeration and drainage through their burrows. It is now understood that the vast majority of the world's decaying vegetable matter passes through the gut of earthworms in the process of recycling nutrients. Our studies have shown that worm numbers and biomass have increased significantly in minimum-tilled winter barley plots relative to conventional-tilled plots. Worm populations further increased when straw was incorporated into plots of either method of cultivation. Yet another interesting development regarding earthworms is the finding of increased occurrence of the more beneficial deep-burrowing worms (e.g. *Lumbricus terrestris*) in minimum-tilled plots. It would seem that this trend is set to continue, since immature worms of this genus are also more abundant in the minimum-tilled plots.

Ground beetles

Ground beetles belong to the family Carabidae and are abundant in arable fields all over the world. The vast majority of these beetle species are beneficial in arable land, since they are generalist predators that feed on a wide range of crop pests. Our investigations on the effects of method of cultivation on the occurrence of ground beetles, while incomplete, indicate that while total beetle density seems unaffected, the relative abundance of particular species may be greatly affected. Larger species, such as *Pterostichus melanarius*, which overwinters in fields as soil-dwelling larvae, are much more abundant in min-till plots relative to conventional-till plots, while small beetles such as *Bembidion spp.* are more numerous in conventional-till plots. It seems likely that the reduced soil disturbance of the min-till system is less harmful to the relatively fragile larval

overwintering species. Earlier work, at Oak Park and elsewhere, has shown that many ground beetle species feed on aphids, springtails (Collembola), fly (Diptera) eggs and larvae, slugs and slug eggs, and some species of weed seeds. A major part of our studies at Oak Park has been the development of sensitive molecular techniques that can detect aphid DNA in field-captured adult beetles and their immature larval stages. It is hoped to further develop and use these tools in ongoing field experiments, in collaboration with UCD, to investigate and better understand the relative ecological benefits of minimum soil tillage compared with conventional soil tillage systems.

This research is sponsored by the National Development Plan.

Clockwise from top left: **Dr Tom Kennedy** is a Senior Research Officer in the Crops Research Department, Teagasc, Crops Research Centre, Oak Park, Carlow. **John McDonald** completed his PhD as part of a Teagasc Walsh Fellowship. **John Connery** is an Experimental Officer in the Crops Research Department, Teagasc, Crops Research Centre, Oak Park, Carlow. **Tony Fortune**, now retired, was a Principal Research Officer in the Crops Research Department, Teagasc, Crops Research Centre, Oak Park, Carlow. **Dermot Forristal** is a Senior



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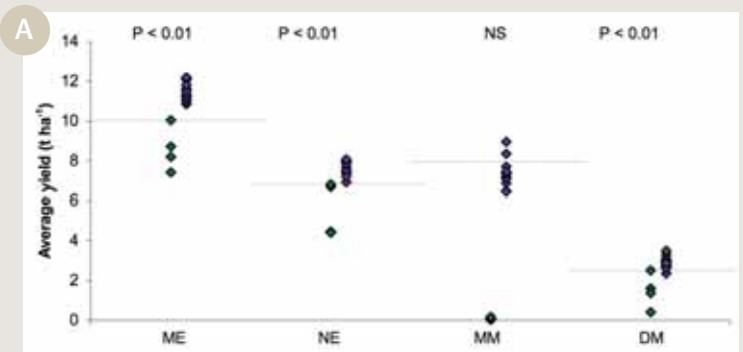
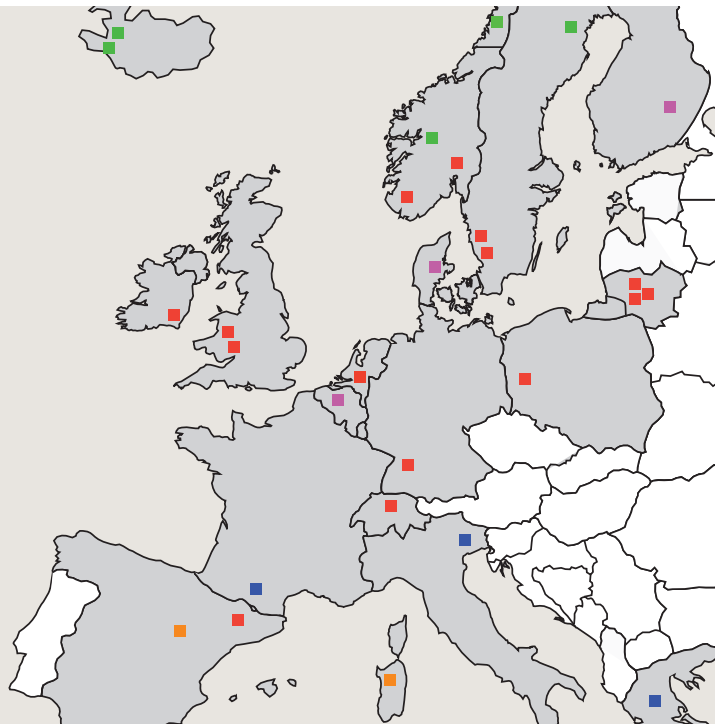


FIGURE 1 (left): Location of 28 sites in the COST 852 study. Monocultures and mixtures of four species were sown at each site. The choice of species depended on the geographical area, with 15 using a mid-European species group (red), five Northern European (green), three moist-Mediterranean (blue) and two dry-Mediterranean (orange). Three sites did not use a standard species group (pink).

FIGURE 2 (above and right): Average over sites for (a) mean yield and (b) mean weed proportion for 11 mixtures (purple) and four monocultures (green) for the four species groups: mid-European (ME), Northern European, moist-Mediterranean (MM) and dry-Mediterranean (DM) and an 'other' group that did not use species in a standard species group.

Sward diversity in intensive grasslands – increased yield and reduced weeds

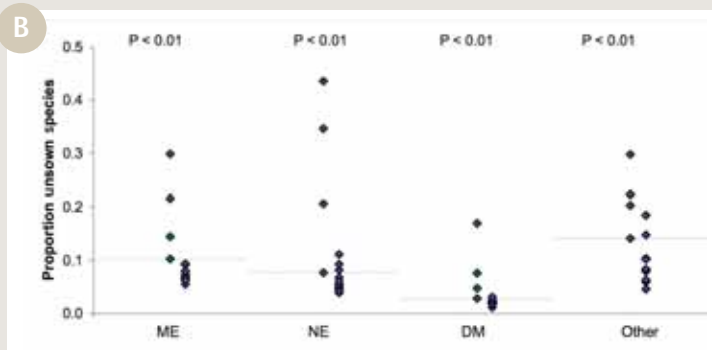
A team of Irish scientists from Teagasc and UCD has led the publication of the largest ever study of the relationship between plant diversity and ecosystem function. LAURA KIRWAN, JOHN FINN, CAROLINE BROPHY and JOHN CONNOLLY explain how a pan-European experiment shows that sward diversity improves yield and reduces weed invasion in agricultural grasslands.

Agricultural systems depend on a range of ecosystem functions, such as efficient recycling of nutrients, maintenance of soil fertility, decomposition of waste products and the provision of natural resources, including the production of food, timber and fibre. There is significant scientific interest in the importance of biological diversity in supplying these essential processes in agricultural systems. Research on the relationship between plant diversity and ecosystem function (diversity–function) has largely used plant species from semi-natural grassland systems, in which reductions from high to low diversity generally result in reduced yield. Ecological principles from diversity–function research therefore suggest that increasing plant species diversity in agronomic systems may improve biomass production, but this has not been extensively tested. The potential multiple benefits of diverse agronomic crops with more than two species are under-researched, but could have important implications for more sustainable agricultural practices by providing sufficient crop yield while minimising environmental impacts.

International study

As part of a European project (COST Action 852), a team of Irish scientists has led the publication of the largest ever international study of the relationship between plant diversity and ecosystem function (Kirwan *et al.*, 2007). Conducted at 45 sites across Europe (almost 20 countries), Canada and Australia, results from the first year at 28 of the sites (see **Figure 1**) are reported in the May issue of the *Journal of Ecology*.¹ A common field experiment of 30 plots, where two legume and two grass species were sown, was established at each site. We used a design with four monocultures (single species) and 11 mixtures (with systematically varying proportions of four species).

The results indicate strong benefits of sward diversity in intensive grassland systems across Europe. Mixtures provided more forage yield than would be expected on the basis of the species' performances in monoculture. The extent of this benefit of diversity was related to the evenness of the mixture: a four-species mixture with an even abundance of 25% of each species



The Irish COST 852 site located at Johnstown Castle, Wexford.



Perennial ryegrass monoculture (left) and mixture containing two grasses and two legumes (right).

performed better than a four-species mixture dominated by one of the species. Averaged across multiple sites, we found that the performance of mixtures generally exceeded that of the best performing monoculture (Figure 2). Mixtures also strongly reduced the incidence of weeds in the sward.

Species complementarity

These data are consistent with complementarity among species whereby more diverse plant swards are better able to capture both light and soil nutrients than less diverse swards, through variation in the leaf and stem architectures, and distribution of roots in the soil, respectively. It is well known that nitrogen fixation by legumes can enhance biomass production of a grass sward, but this study also showed complementarity between different grass species.

Novel modelling approach

The methodology – developed by the collaboration between University College Dublin and Teagasc – represents a novel approach to modelling the effects of diversity, and helps resolve several problems that have beset the analysis of diversity–function relationships in ecological experiments. This methodology is appropriate for addressing other questions about the effect of changes in diversity on selected environmental processes, such as the reduction of nitrogen leaching, the control of invasive weeds and the production of biofuels.

Future work

The COST 852 project officially finished in late 2006, but a postdoctoral fellowship funded by the Irish Research Council for Science, Engineering and Technology (IRCSET) allows further analysis to be conducted on the extensive dataset that has been produced from the project. The wide range of climatic

and soil conditions across so many sites allows us to investigate how environmental conditions influence the relationship between diversity and ecosystem function, and this may facilitate forecasting of the agricultural impacts of future climate change. Other questions that will be addressed include: the degree of persistence of the diversity benefits (for yield and weed reduction) over time; the value of sward diversity in low-input clover-based systems on forage quality for animal production; the effect of sward diversity on nitrogen dynamics; and, the effect of plant diversity on insect and microbial biodiversity.

Reference

1. Kirwan, L.A., Lüscher, M.T., Sebastià, J.A. *et al.* 2007. Evenness drives consistent diversity effects in intensive grassland systems across 28 European sites. *Journal of Ecology*, 95: 530-539.

Dr Laura Kirwan and **Dr John Finn** (Teagasc Environment Research Centre, Johnstown Castle), and **Dr John Connolly** and **Caroline Brophy** (School of Mathematical Sciences, UCD), are members of the Environmental and Ecological Modelling Group, which combines statistical modelling skills with ecological expertise. Dr Kirwan is grateful to IRCSET for a postdoctoral fellowship award, hosted by Teagasc, Johnstown Castle. E-mail: laura.kirwan@teagasc.ie.



T Environment



The grey partridge has undergone a significant decline since 1900 due to changes in farming methods. Planted grain crop for birds.

Reversing the decline of farmland birds

Intensification of agriculture has led to a decline in farmland bird species. DAIRE Ó HUALLACHÁIN reports on work at Johnstown Castle that aims to reverse this trend.

TABLE 1: Red List* criteria and species

Red Listed species meet one or more of the following criteria:

- their breeding population or range has declined by more than 50% in the last 25 years;
- their breeding population has undergone a significant decline since 1900; or
- they are of global conservation concern.

The Irish Red List species are as follows:

Black-necked grebe	Corncrake	Nightjar
Common scoter	Lapwing	Ring ouzel
Hen harrier	Curlew	Chough
Red grouse	Red-necked phalarope	Twite
Grey partridge	Roseate tern	Yellowhammer
Quail	Barn owl	Corn bunting

*International Union for the Conservation of Nature and Natural Resources classification.

There have been dramatic changes in European agricultural management strategies in recent decades. Foremost among these was the introduction of The Common Agricultural Policy (CAP), which resulted in traditional extensive farming methods giving way to more intensive management. Intensification had a particularly negative impact on farmland birds. Currently, 12 of the 18 birds on the Irish Red List (Table 1) are associated with agricultural habitats. Many farmland birds, such as the grey partridge and the yellowhammer, have undergone significant reductions in their numbers and range. The corn bunting, a bird found on extensive arable land, is now considered extinct in Ireland. The corncrake, once a bird commonly associated with meadows, is threatened with global extinction.

Addressing the issue of biodiversity loss

Major environmental and biodiversity problems in recent decades culminated in the 1992 Rio Convention on Biological Diversity, which aimed to reverse the decline in biodiversity. The World Summit on Sustainable Development declared in 2002 that by 2010 there should be a significant reduction in the current rate of loss of biological diversity. Ireland, having ratified the Rio Convention, is therefore obliged to sustain and enhance its biodiversity. Recent decades have seen Ireland attempt to halt biodiversity loss with the establishment of different approaches that positively affect farmland bird populations. The first approach is to reintroduce species into areas where they formerly occurred but have since become extinct. The second is to conserve species that are present, but threatened with extinction.

Species reintroduction

Reintroduction projects have received much publicity in recent years. In 2001, a programme was instigated to reintroduce the golden eagle to Donegal. The outcomes of the project have been promising, culminating this year in the first wild hatching of a golden eagle chick in Ireland in almost a century. Following the success of the golden eagle project, plans are now afoot to reintroduce more raptors to the country, i.e., the white-tailed eagle to Killarney and the red kite to Wicklow. There are also plans to reintroduce non-raptors, such as woodpeckers.



Crop of Brassicas for birds.

However, while reintroduction projects are important in their own right, global evidence indicates that these projects have a high failure rate. The particular challenge is addressing the environmental stresses that caused the extinction in the first place. These need to be addressed if the reintroduction is to be successful. This can often be a costly exercise; often the time and effort involved would be better invested in protecting the species that are presently on the brink of extinction. From a biodiversity point of view, it is easier to conserve than restore.

Farmland bird conservation measures

Conservation efforts directly aimed at stopping the decline of farmland birds are of considerable importance. Supplementary Measure 1 in REPS (Rural Environment Protection Scheme) and work by Birdwatch Ireland has resulted in a halt in the decline of the corncrake in this country and, indeed, a small increase in its population in a number of areas.

Arguably the best-known conservation measure aimed at protecting farmland birds is LINNET (Land Invested in Nature Natural Eco-Tillage). This

measure aims to encourage the small-scale production of cereal plots, especially in areas dominated by grassland. LINNET provides an over-wintering source of seeds and insects for a variety of bird species and is the most popular of all REPS supplementary measures, with over 2,000 hectares incorporated in the scheme.

Food availability for young and winter survival of adults and young are believed to be the most limiting factors for many of our threatened farmland bird populations. By providing a food source such as grain (and the insects associated with grain), LINNET addresses the main resource requirements of farmland birds, i.e., breeding-season food, nest sites, cover and winter food. This will therefore help conserve threatened farmland bird populations and reverse the current rate of decline. LINNET crops also provide food and cover for a variety of other farmland fauna, such as insects and mammals, many of which have also undergone decreases in population in recent decades.

Researchers are currently examining measures aimed at enhancing existing LINNET guidelines (Table 2). These measures include increasing the area of plots to greater than the guideline of 2.5ha. In addition, although current guidelines for plant composition (20% Brassica and 80% grain) undoubtedly provide benefits to farmland birds, it would be worth investigating whether a greater variety of plant species in different proportions might yield greater wildlife benefits.

Planting of grain crops

Experimental trials from the South Slob, Wexford, where plots have been planted with grain crops for birds, are revealing promising results. These indicate that a significantly greater abundance of birds is found in areas planted with grain crops for birds compared to the conventional crops, e.g., there was an average of 32 birds per 100m transect in the grain crop for birds in winter, compared to two birds per 100m in the conventional crop. Even small areas of land planted with grain crops for birds can provide a valuable winter food source for large numbers of birds. This winter food source is of particular importance because during this time, most agricultural crops have been harvested and subsequently gleaned of any

TABLE 2: Current management guidelines for LINNET and potential improvements.

LINNET	Potential improvements
<ul style="list-style-type: none"> ■ Crop must be 20% Brassica and 80% cereal; ■ area must be between 0.5ha and 2.5ha; ■ crop must be on the same ground for five years of plan; ■ seed must be spring sown before May 31; and ■ crop must be stock-proof and must not be harvested. 	<ul style="list-style-type: none"> ■ Crop may contain any seed-bearing plant deemed suitable for birds and not limited to 20% Brassica and 80% cereal; ■ there is no limit to the area that may be planted; and ■ crop may be rotated from year to year around the farm.



Yellowhammer populations have declined by more than 50% in the last 25 years.

remaining food and, most trees and plants no longer bear any fruit or seeds. Therefore, measures such as planting land with grain crops for birds will provide an alternative food source at a period of low food availability. Results from studies on the South Slob indicate that a large number and variety of birds visit the areas of grain crops for birds, particularly in the period from October to March. Flocks of over 1,500 seed-eating birds were regularly noted. The crops not only support a large abundance of birds but also support a rich diversity of birds, e.g., 11 different bird species were counted in one 100-metre section.

The crops are not only important to small farmland species such as yellowhammers, but also to threatened birds of prey that feed on farmland birds. Visits to the site in Wexford have identified red kites (extinct as a breeding bird in Ireland for almost 200 years), marsh harriers (extinct as a breeding bird in Ireland for almost 100 years), hen harriers (Red Listed species), buzzards and peregrine falcons feeding over the areas of planted bird crops, in addition to more common raptors such as kestrels and sparrow hawks.

Planting of LINNET, particularly in areas dominated with grassland, or the sowing of small plots of land with grain and seed-bearing crops for birds, would undoubtedly yield an increased bird population and benefit many of our Red Listed species. As agricultural systems change, Teagasc research will continue to develop further viable measures that can be incorporated in the wider agricultural landscape to protect and enhance our native biodiversity.

Acknowledgments

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The Walsh Fellowships Programme

Introduction to the Walsh Fellowships programme

The Teagasc Walsh Fellowships programme for postgraduates offers a unique opportunity to young graduates to undertake MSc and PhD research programmes in agriculture, food, environmental science, agri-food economics, rural development, horticulture and other related disciplines.

There are a total of 150 ongoing fellowships, with a turnover of up to 50 new postgraduates each year. The programme is named after Dr Tom Walsh, the first Director of both the Agriculture Research Institute and the National Advisory and Training Service (ACOT), which were merged in 1988 to form Teagasc.

Objectives of the Walsh Fellowships Programme

- to provide research training and professional development for young scientists in agriculture, food and related disciplines, leading to the acquisition of a higher degree;
- to facilitate liaison between Teagasc's applied research programme and the more basic or fundamental investigations in the third-level sector; and,
- to establish 'new science' areas in Teagasc in response to changing priorities.

Applying for a Walsh Fellowship research project vacancy

Applications for Walsh Fellowships are made each year by academic staff in third-level institutes in co-operation with Teagasc researchers on topics relevant to Teagasc's research priorities. Successful applicants then recruit postgraduate students to the fellowships. Project applications are not accepted from individual postgraduate students and the programme does not fund taught (non-research) postgraduate programmes.

Successful university applicants advertise and recruit postgraduate students to conduct approved MSc and PhD programmes in conjunction with Teagasc. A list of current Walsh Fellowship vacancies is available on Teagasc's website via the Walsh Fellowship homepage under the hyperlink "Current postgraduate research opportunities".

Further information

Further information regarding the Walsh Fellowships programme, including the list of the priority research areas established for 2007 and also the list of all Walsh Fellowship projects approved in 2007, can be found on Teagasc's public website – <http://www.teagasc.ie/research/postgrad/index.htm>

T Events

August

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.eaap2007.ie. eaap2007@ovation.ie

August 30 *Teagasc Oak Park, Carlow*

Bioenergy 2007 – Fuelling Ireland's Future

This event aims to promote solid biomass (forestry, willow, miscanthus) and to create and boost the confidence of all players in the supply chain from growers and suppliers to users. This is a joint Teagasc/SEI/COFORD/WIT event. It is aimed at farmers and growers, the agri-community, policy makers, energy users, trade and the general public. www.teagasc.ie/events. barry.caslin@teagasc.ie

September

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 19 *Glenview Hotel, Glen of the Downs, Co. Wicklow*

Forestry, Carbon and Climate Change – Local and International Perspectives

Organised by Coford. www.coford.ie. info@coford.ie

September 25-27 *Annaharvey Farm, Tullamore, Co. Offaly*

National Ploughing Championships

Annual event organised by the National Ploughing Association. www.npa.ie. Tel: 059 862 5125 info@npa.ie

September/October

September 29 – October 4 *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. info@wds2007.com

October

October 3 *Tullamore Court Hotel, Tullamore*

National Tourism/Artisan Food Conference

John McKenna, food writer and broadcaster, will head an international list of speakers at this conference, which will be officially opened by the Minister for Community, Rural and Gaeltacht Affairs, Éamon Ó'Cuív TD. The conference will signpost the opportunities for development in tandem between the artisan food and rural tourism sectors. www.teagasc.ie. gerry.scully@teagasc.ie

October 17-18 *W5 science and discovery centre, Belfast*

Tellus Conference 2007

This conference features the results of recent geoscience surveys covering all of Northern Ireland. Airborne and ground surveys completed in 2006 reveal new information about the region's environment and natural resources.

www.detini.gov.uk

Tel: 048 9038 8462, or tellusconference@detini.gov.uk

October 18 *Cork*

Open Innovation Seminar

Half-day seminar featuring an international speaker with direct experience of open innovation. Other speakers will include key Irish companies and research groups, who will also share their hands-on knowledge and experience of innovation.

www.enterprise-ireland.com

Jim.Cuddy@enterprise-ireland.com

October 22-28 *Nationwide*

National Organic Week

This Bord Bia initiative aims to continue raising consumer awareness of organic food.

www.bordbia.ie

October 22-24 *Cavan (22) | Kilkenny (23) | Moorepark (24)*

Teagasc national pig conferences

A panel of national and international speakers will cover topics including: how much protein is enough; feed costs for weaned pigs; getting growing – finishing pigs to eat more; observations on the Danish pig industry; effects of failure to meet cash flow projections; on-farm options for euthanasia; high fibre diets for sows; worm control in sows; world grain market; and the pig industry, manure handling and biogas production.

www.teagasc.ie

ciaran.carroll@teagasc.ie; brendan.lynch@teagasc.ie

November

November 11-18 *Nationwide*

Science Week

Part of Forfás' Discover Science & Engineering (DSE) initiative, the week aims to increase interest in science, technology, innovation and engineering among students, teachers and members of the public.

www.scienceweek.ie

For Teagasc Science Week events: catriona.boyle@teagasc.ie

November 21-22 *Kilkenny/Castlebar*

Teagasc National Dairy Conferences

This year's theme is 'Freedom to milk'. With the expectation that dairy quotas will be phased out from 2009, an opportunity exists for Irish farmers to increase milk production. Grass-based milk production systems give Irish farmers a comparative advantage. A panel of national and international speakers will explore how farmers can best utilise their resources in this new business environment.

www.teagasc.ie

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