



TEAGASC

Research

Volume 8: Number 1. Spring 2013

ISSN 1649-8917

Research and innovation news at Teagasc www.teagasc.ie



Promoting phosphorus in soils

Renewed emphasis on agri-food research funding
Breeding for quality
Lessons for effective and efficient knowledge transfer



AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

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Future Agri-Food

Science Foundation Ireland (SFI) and Teagasc have come together to launch a themed call, Future Agri-Food, as part of the 2013 SFI Investigators call. This collaboration agreement between the two agencies aims to strengthen and accelerate research and innovation in the agri-food sector through the funding of grants between scientists from the agriculture and food disciplines and scientists from other scientific and engineering disciplines. The joint initiative aims to bring a broad range of disciplines and technologies to bear on strengthening innovation in the agri-food sector and to offer opportunities to scientists in a wide range of disciplines including genomics, robotics, material science, nanotechnology, immunology and ICT.

Ireland has developed fantastic capacity across a broad range of scientific disciplines in recent years (including agriculture and food) and the convergence of this broad range of disciplines on agri-food topics will help underpin the profitability, competitiveness and sustainability targets set out in Food Harvest 2020.

This themed call has been developed in the context of the recent National Research Prioritisation Exercise, which identified a number of areas, including agri-food, of greatest economic and enterprise potential for Ireland. This call will target two of those areas: 'Sustainable Food Production and Processing' and 'Foods for Health'. A strategic aim of the call is to prepare the Irish scientific community to compete, lead and win in relevant Horizon 2020 funding programmes and other relevant international funding programmes.

Applications under the themed call must be multidisciplinary in nature and, to drive collaboration, it is a condition of the call that there must be at least two partners (one of which must be from Teagasc), each of which must be responsible for at least 30 percent of the budget in the application. We look forward to exciting proposals under this initiative and to the building of new collaborations that will strengthen and accelerate research and innovation in the agri-food sector.



Dr Frank O'Mara

Director of Research, Teagasc
Teagasc Head Office, Oak Park, Carlow

Agraibhia sa Todhchaí (Future Agri-Food)

Tháinig Fondúireacht Eolaíochta Éireann (SFI) agus Teagasc le chéile chun glao téamaithe, Future Agri-Food, a lainseáil mar chuid den ghlaio um Imscrúdaitheoirí SFI 2013. Tá sé d'aithm leis an gcomhaontú comhoibrithe seo idir an dá ghníomhaireacht taighde agus nuálaíocht san earnáil agraibhia a neartú agus a luathú trí mhaoiniú deontas idir eolaithe ó na disciplíní talmhaíochta agus bia agus eolaithe ó dhisciplíní eolaíochta agus innealtóireachta eile. Leis an gcomhthionscnamh tá sé d'aithm raon leathan disciplíní agus teicneolaíochtaí a sheachadadh chun nuálaíocht a neartú san earnáil agraibhia agus chun deiseanna a thabhairt d'eolaithe i raon leathan disciplíní lena n-áirítear géanómaíocht, róbataic, eolaíocht na n-ábhar, nanaitheicneolaíocht, imdhíoneolaíocht agus TFC.

Tá acmhainn iontach forbartha in Éirinn ar fud raon leathan disciplíní eolaíochta le blianta beaga anuas (lena n-áirítear talmhaíocht agus bia) agus cuideoidh coinbhéirseacht an raoin leathain disciplíní seo maidir le topaicí agraibhia le taca a chur faoi spriocanna brabúsachta, iomaíochais agus inbhuanaitheachta mar atá leagtha amach i bhFómhar Bia 2020 (Food Harvest 2020).

Forbraíodh an glao téamaithe seo i gcomhthéacs na Gníomhaíochta Náisiúnta um Beartú Tosaíochta Taighde, inar saináithníodh roinnt réimsí, lena n-áirítear agraibhia, de mhór-acmhainneacht eacnamaíoch agus fiontraíochta d'Éirinn. Díreofar ar dhá cheann de na réimsí sin sa ghlaio seo: Táirgeadh agus Próiseáil Bia Inbhuanaithe' agus 'Bia don tSláinte'. Is é ceann d'aithm straitéiseach leis an nglao seo pobal eolaíochta na hÉireann a ullmhú chun cláir mhaoiniúcháin ábhartha Deiseanna Nua 2020 a chur i gcrích, a stiúradh agus a bhuachan mar aon le cláir mhaoiniúcháin idirmáisiúnta ábhartha eile.

Ní mór do na hiarratais faoin nglao téamaithe a bheith de chineál idirdisciplíneach agus, comhoibriú a spreagadh, is coinníoll den ghlaio é go gcaithfidh dhá chomhpháirtí ar a laghad a bheith ann (agus caithfidh comhpháirtí amháin a bheith as Teagasc), agus beidh gach duine díobh freagrach as 30 faoin gcéad ar a laghad den bhuiséad san iarratas. Táimid ag súil le tograí corraitheacha faoin tionscnamh seo agus le comhoibriú a fhorbairt ina ndéanfar taighde agus nuálaíocht san earnáil agraibhia a neartú agus a luathú.

An Dr. Frank O'Mara

Stiúrthóir Taighde, Teagasc
Príomhoifig Taighde, Páirc na Darach, Ceatharlach

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Published on behalf of Teagasc by:

IFP Media, 31 Deansgrange Road, Blackrock, Co. Dublin.
t 01-289 3305 f 01-289 6406 www.ifpmedia.com
Design: Martin Whelan
Editorial: Miriam Atkins



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Professor Catherine Stanton

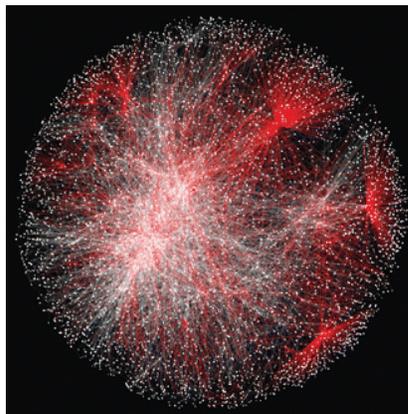
Catherine Stanton is a Principal Research Officer at Teagasc's Food Research Centre in Moorepark, Fermoy. A native of Kilworth, a village that's just a couple of miles from the Moorepark facility, she joined Teagasc in 1994 as a Research Officer.

Catherine's research is concentrated on developments in functional foods to influence of gut microbiota and selection of probiotics for potential health benefits. She says: "Our work centres primarily on probiotic cultures, their health benefits through bioactive metabolite production and technological aspects of probiotics." Her primary degree, which she received from University College, Cork (UCC), in 1983, is in Nutrition and Food Chemistry. In 1986, she received her M.Sc in Nutrition, also from UCC.

Catherine completed a PhD in Biochemistry at Bournemouth University in the UK in 1988. Subsequently, she undertook her Postdoctoral Fellowship at the Department of Medicine, Wake Forest, University Medical Center, Winston-Salem in North Carolina in the US in 1990.

Catherine received D.Sc. (2009), based on published work, and, the following year, was a joint recipient – with Paul Ross, Colin Hill and Gerald Fitzgerald – of the Elie Metchknoff Award for research on the application of lactic acid bacteria (LAB) in fermented dairy products to improve health and mechanistic basis of LAB and probiotic functionality.

Named APC Scientist of the Year in 2011, Catherine was appointed Adjunct Professor in the College of Medicine and Health, Department of Psychiatry, UCC in 2012.



Grange Bioscience paper on cover of NAR

A paper featuring Scientists from Teagasc Grange's Animal and Bioscience Department (Dr David Lynn and Teagasc Walsh Fellow Amir K. Foroushani) has featured as the cover image of the journal *Nucleic Acids Research*. The cover figure illustrates the >18,000 molecular interactions relevant for the innate immune response that have been manually annotated by the InnateDB database. InnateDB is a contextual repository and analysis platform that has been developed to facilitate systems level analyses of innate immunity and beyond. For further information, please see the article 'InnateDB: systems biology of innate immunity and beyond — recent updates and continuing curation' by Breuer et al.: <http://nar.oxfordjournals.org/content/41/D1/D1228.full>

Teagasc National Tillage Conference

Speaking at the Teagasc National Tillage Conference, Steven Kildea, plant pathologist in Teagasc, commented on the latest news on disease resistance to fungicides, saying: "We have been warning the industry for some time that the SDHI group of fungicides, which are an important component of all the most recently released cereal fungicides, are at high risk of resistance development. This has recently been confirmed with the discovery of a Septoria isolate and two Net Blotch isolates on the continent with reduced sensitivity or partial resistance to the SDHI's. None have been found in Ireland, but this emphasises the need for using them carefully to avoid resistance development. They should be used no more than twice in a season and should always be used with a robust rate of a triazoles and a multi-site fungicide, e.g., chlorothalonil or folpet." Teagasc researcher Dermot Forristal outlined to farmers how machinery costs in Ireland on 'mainly tillage' farms, as identified by the Teagasc National Farm Survey, are approximately 20% higher than those on UK farms and he warned that this competitive disadvantage needs to be addressed. John Spink, Head of Crops Research in Teagasc announced that Teagasc tillage specialists and advisers will be providing a new service to farmers. Regular updates on the growth stages of wheat crops will be posted on the Teagasc website www.teagasc.ie Tillage specialist Tim O Donovan said: "These regular growth stage updates and aphid counts will help growers to improve the effectiveness of the plant protection strategies employed, through improved timing of spraying operations."

Teagasc leads the way in the development of robotic milking for grazing dairy cows

Teagasc Moorepark - in association with partners from Ireland, Sweden, Denmark, Netherlands, France and Belgium - will develop technology integrating robotic milking with grazing dairy cows over the next three years. The project, AUTOGRASSMILK, is funded by the EU FP7 programme under 'Research for the benefit of SME Associations' and is worth €3.1 million in total. The project is being co-ordinated by Dr Bernadette O'Brien of Teagasc Animal & Grassland Research and Innovation Programme, Moorepark. The group includes six European associations of dairy farmers/producers/processors and six research organisations (Wageningen UR Livestock Research, the Netherlands; Aarhus University, Denmark; Institute de l'Élevage, France; University of Liege, Belgium; Swedish University of Agricultural Science, Sweden and Teagasc Moorepark Ireland) as well as two commercial dairy farms, one each in Ireland and Denmark. The Irish SME association is the Irish Grassland Association. In robotic milking, cows come voluntarily to the milking unit and milking is distributed over a 24-hour period. Increasingly, dairy farmers in most EU countries have adopted robotic milking for reasons such as improvement in

lifestyle, less physical work and lower labour costs. However, this has been associated with a decrease in cows grazing with a corresponding increase in indoor feeding systems. As grazing has many advantages in terms of lower costs, improved environment, better animal welfare and higher quality milk, the objective of this project will be to develop a grass-based system of milk production using robot milking. Currently, there are only a small number of farms with robotic milking technology in Ireland (approximately < 20). Food Harvest 2020 recommends an increase of 50% in milk production by 2020 and robotic milking could significantly assist in achieving this goal. A Fullwood Merlin robot-milking unit has been installed at Teagasc/Dairygold Research farm to conduct the research. The application of project findings will be targeted towards the dairy farmer, producer associations, their members who are engaged in dairy farming, and thereafter all EU dairy farmers. Dissemination will be via Teagasc advisory service using farm visits with discussion groups assisted by website, fact sheets, seminars and conferences, and scientific papers.



TAP visits Grange

A group of students from inner city schools on the Trinity Access Programme (TAP) recently visited Teagasc Grange Research Centre to learn about the importance of the agri-food industry and were given a farm tour. The programme aims to encourage young adults and ethnic minority students from socio-economic groups under-represented in higher education, to go to university. The students are pictured with some Teagasc Walsh Fellows, and their TAP programme manager, Kathleen O'Toole-Brennan.

New multinational wheat initiative

Representatives from governmental and non-governmental organisations across the world have agreed to establish a new multinational initiative - the Wheat Yield Network (WYN). The Network will support research and development activities to raise global wheat yields and develop new varieties adapted to different geographical regions. The WYN has been established within the framework of the G20 sponsored Wheat Initiative.

Teagasc's John Spink is Ireland's representative. For more see: www.wheatinitiative.org

Teagasc Gold Medal award

The Teagasc Gold Medal in Agriculture and Food Science for 2012 was presented to Dr Lance O'Brien, Head of the Teagasc Foresight and Strategy Department. The Teagasc Gold Medal is awarded on an annual basis to a serving staff member who has made an outstanding contribution to the organisation over a long period. The Gold Medal was awarded to Dr O'Brien in recognition of the substantial contribution he has made over a long and distinguished career across a broad range of Teagasc functions.

Dr O'Brien was Project Manager of the major Teagasc Foresight exercise – Teagasc 2030 – Teagasc's Role in Transforming Ireland's Agri-Food Sector and the Wider Bioeconomy, published in 2008. He has contributed to national and international research policy and foresight initiatives, including Food Harvest 2020. He is a member of the national organising committee for the Dublin 2013 EU conference on 'Bioeconomy in the EU: achievements and directions for the future'. He was a member of the Third EU Standing Committee on Agricultural Research (SCAR). Foresight Expert Group.

Teagasc research – an EU success story

Two Teagasc research projects are featured in the '500 success stories of European research', recently published on the European Commission's Research and Innovation website.

Building on this extensive participation, one of the PEN project's key successes was the creation of a single platform to disseminate information and expertise about *E. coli* around the world, for the benefit of everyone involved in the effort to understand and manage this threat - from microbial researchers to regulators, legislators, the food industry and public health experts. The project went on to develop science-based risk-management strategies tailored for use both by farmers and by the food-processing industry, and provided information and guidance for public health professionals and regulators on ways to detect, assess and manage newly emerging strains of *E. coli*.

The END-O-SLUDG project started in January 2011. Its work is still in its relatively early stages, but already it has made notable progress. In order to reduce the volume of sludge produced in wastewater, one promising technique END-O-SLUDG scientists are investigating is Dissolved Air Flotation (DAF). Already in pilot trial phase, DAF exploits the tendency of certain materials to bind to air bubbles. By injecting a flow of micro-bubbles into wastewater, DAF offers the possibility of 100% removal of one of the key components of sludge, known as Total Suspended Solids - compared with 65% reduction achieved through existing methods. For more details on both projects see: http://ec.europa.eu/research/infocentre/success_stories_en.cfm?item=Countries&subitem=Ireland



Eco Eye

Teagasc researchers Dr Gary Lanigan and Dr Laurence Shalloo featured in a recent episode of the television series Eco Eye presented by Duncan Stewart on RTÉ1. The episode concentrated on the issue of sustainability and, in particular, reducing greenhouse emissions. It focused on the complete chain from research to farmers to processors and to the market for our produce. Episode 2 'Greening Ireland' can be seen on <http://www.youtube.com/user/TeagascMedia>

Dr Laurence Shalloo (right), Teagasc, Animal and Grassland Research & Innovation Centre, Moorepark with presenter Duncan Stewart.



NetGrow project

Dr Maeve Henchion, Head of Department, Agrifood Business and Spatial Analysis, Teagasc Rural Economy Research Centre; Professor Xavier Gellynck, Co-ordinator NetGrow, University of Gent; Lucinda Creighton, Minister of State for European Affairs; Bridin McIntyre, Dr Douglas Sorenson and Beste Yildiz, Teagasc Walsh Fellow, Agrifood Business and Spatial Analysis Department, Teagasc.

Lucinda Creighton, Minister for European Affairs, met the NetGrow project consortium during a recent meeting, with representatives from nine European countries, in Dublin recently. Teagasc, represented by Dr Maeve Henchion, Dr Douglas Sorenson, Bridin McIntyre and Beste Yildiz (Walsh Fellow) is a key partner of this leading pan-European research group, which will develop new strategic management tools to support food SMEs – and agencies that support their activities

– to become more innovative. During the three-day meeting the group reviewed the current stage of the research and undertook some key steps to translate the research findings into practical tools. The food industry is the focus of the project for a number of reasons including its importance to both the EU's and Ireland's economy, its low rate of innovation, coupled with high new product failure rate after market introduction and its high proportion of SMEs.

UCC appoints research professors

Professor Paul Ross of Teagasc is one of three leading researchers to be appointed a Research Professor at University College Cork. Professor Ross has been appointed as a Research Professor within the Alimentary Pharmabiotic Centre. His appointment acknowledges his research achievements in gut microbiota, antimicrobial peptides, bacteriocins, probiotics, and anti-infectives. Professor Gerry Boyle, Director of Teagasc, in welcoming the appointment says: "This appointment reflects the on-going productive collaboration through the UCC-Teagasc Strategic Alliance in Food Research launched in 2010."

Professor Cian Ó Mathúna along with Professor Paul Townsend, both researchers in the Tyndall National Institute, were also appointed as Research Professors in Electrical Engineering and Physics, respectively.

Largest number of awards ever under the 2013 Walsh Fellowship Programme

The Teagasc Authority announced the award of 64 new postgraduate fellowships, mainly to PhD level, under its Walsh Fellowship Postgraduate Programme. This is the largest number of approvals made since the commencement of the Programme and reflects the increasing number of high-quality proposals received and the Authority's acknowledgement of the huge impact of the Programme on research output. These awards represent an overall investment of over €4 million in training the scientists who will help drive forward Ireland's growing agri-food industry. The new graduates will join about 140 existing Walsh Fellows, under the joint supervision of Teagasc and University staff members in undertaking research in agriculture, food, environmental science, agri-food economics, rural development, horticulture and other related disciplines.

The Programme is a key component of Teagasc's national research programme and promotes closer liaison and collaboration between Teagasc and the

nine universities on the island of Ireland, as well as with Irish Institutes of Technology and universities in Europe, New Zealand and the US.

The postgraduate programme has taken on an increasingly international dimension in recent years and twelve of the 2013 awards will involve students training in universities outside of Ireland. Professor Gerry Boyle, Director of Teagasc, says: "Science is becoming an increasingly global discipline and it is vital that our best students are exposed to the best international science and research outside of Ireland. I am also pleased to note that, with a view to further broadening this international dimension, Teagasc awarded short-term overseas training grants in 2012 to six current Walsh Fellows to spend short training periods in approved universities and research institutes outside of Ireland, and that up to ten such awards will be made in the current year."

For further details, see: www.teagasc.ie/research/postgrad



Merial award

Congratulations to Kathryn McRae, Teagasc Animal & Bioscience Department, Grange and DCU, the winner of the Merial student award for best presentation at the Irish Society for Parasitology annual meeting 2013. Kathryn's presentation was entitled 'Characterising gastrointestinal nematode resistance in Scottish blackface lambs'. Kathryn is a Teagasc Walsh Fellow with Dr Orla Keane (Grange); Dr Barbara Good (Athenry); Dr Torres Sweeney (UCD); and, Dr Mary O'Connell (DCU). Kathryn is studying the host response to nematode infection.

New Teagasc Authority members

Minister for Agriculture, Food and the Marine, Simon Coveney, appointed three new board members to the Teagasc Authority. Mr Brendan Gleeson, Dr Karina Pierce and Mr Tom Tynan attended their first meeting of the Authority in February. The appointments are for a five-year term.

Mr Gleeson is a Principal Officer in the Meat and Milk Policy Division of the Department of Agriculture, Food and the Marine. Dr Pierce is a Lecturer in Dairy Production in UCD's School of Agriculture and Food Science and a former President of the Agricultural Science Association (ASA). Mr Tynan has held senior management positions in Origin Enterprises, Arysza AG, (formerly IAWS Group plc) and Golden Vale plc. He also worked as Special Adviser to Ivan Yates during his term as Minister for Agriculture, Food & Forestry and was Executive Secretary to the IFA National Dairy and Liquid Milk Committees.

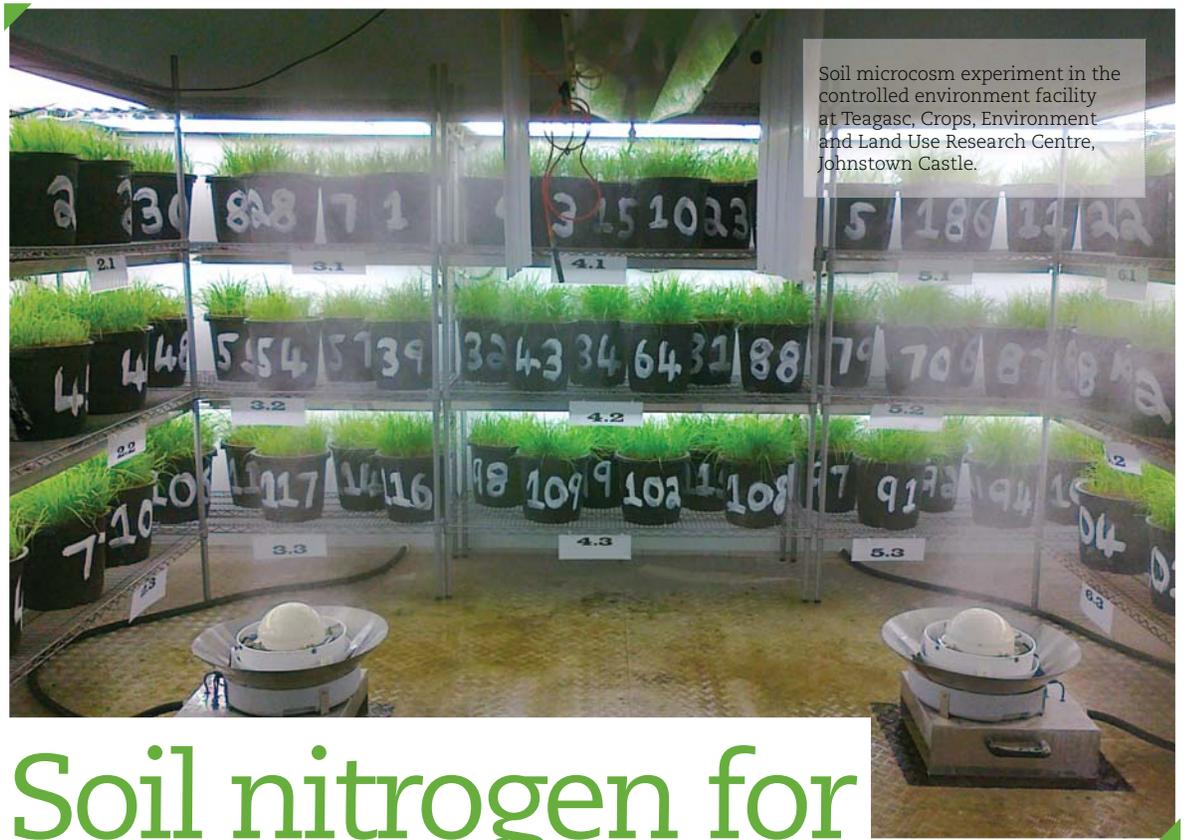


Michael Cantwell, Enterprise Ireland; Dr Frank O'Mara, Teagasc; Minister for Agriculture, Food & the Marine, Simon Coveney; and Tara McCarthy, Bord Bia, at the Food Works Exhibition at Guinness Enterprise Centre.

Minister Coveney meets 11 Food Works entrepreneurs

Minister for Agriculture, Food and the Marine, Simon Coveney visited the Guinness Enterprise Centre, Dublin to meet the Food Works entrepreneurs undertaking the final stage of the Food Works initiative. Minister Coveney commended the rigour of the Food Works approach through which the 11 participants had progressed from the initial Plan your Path information sessions, to the final stage, Begin Your Venture. Food Works is a joint initiative that sees Teagasc, Bord Bia, and Enterprise Ireland pool their resources to support Irish food entrepreneurs.

The inaugural Food Works programme was launched in March 2012 and, to date, Food Works has helped 28 potential entrepreneurs undertake detailed feasibility analysis and 11 develop investor-ready business plans. The second Food Works programme is being launched this coming March, and a call for ambitious and driven entrepreneurs with business acumen has been put out. The closing date for receipt of application is 5pm Monday, April 29, 2013, and application forms can be found on www.foodworksireland.com



Soil nitrogen for efficient grass production

Noeleen McDonald, Teagasc, Walsh Fellow, **Dr David Wall** and **Stan Lalor**, Research Officers, Teagasc, Crops, Environment and Land Use Programme, Johnstown Castle, Co Wexford.

Dr Catherine Watson, Head of the Agri-Environment Branch, Agri-Food and Biosciences Institute, Belfast, Northern Ireland.

Dr Ronnie Laughlin, Agri-Food and Biosciences Institute, Belfast, Northern Ireland.

Professor Chris Elliott, Institute of Agri-Food & Land Use, Queen's University Belfast, Northern Ireland. Correspondence: david.wall@teagasc.ie

Noeleen McDonald was the recipient of the Best Oral Presentation at the Teagasc Walsh Fellowship seminar for her PhD investigating soil nitrogen supply potential in Irish grassland soils

Existing nitrogen (N) fertilizer recommendations for Irish grassland soils are based on a 'one soil fits all' system. This does not consider the varying levels of N that different soils could potentially supply through soil N mineralisation (N_0). This may result in under- or over- application of N fertilizers to fields, leading to poorer economic returns and unnecessary losses of N to the environment.

Since 2010, research investigating the soil N supply potential of 28 Irish grassland soils is being conducted at Teagasc, Crops, Environment and Land Use Research Centre, Johnstown Castle. The aim of this research is to investigate the potential for developing a reliable soil test to predict soil N supply in grassland soils. This research has included experiments at laboratory, microcosm and field scales.

Can soil tests predict soil N supply potential?

The ability to make reliable estimates of soil N supply through N mineralisation (N_0) has long been a goal for those concerned with N fertiliser management in agricultural systems. In temperate grassland systems, the transient nature of N in the soil causes difficulties for predicting more long-term N supplies for grass uptake. Soil N tests, which measure soil N release resulting from biological activity (i.e., N_0), have been shown to be reliable. However, these tests are time-consuming and impractical for routine use. The alternative is to use chemical soil N tests, which are rapid (usually <24 hours), but their reliability to accurately predict N_0 for grassland soils is largely unknown. In order to identify suitable and practical soil N_0 testing methods for Irish grassland soils, a laboratory study was conducted using 28 different grassland soils collected from around the island of Ireland, where a range of rapid chemical soil N tests were compared to a standard biological test for measuring N_0 . The results highlighted the large range in N supply potential of Irish soils, which ranged from 93 to 385 kg N/ha in the top soil to 10cm depth.

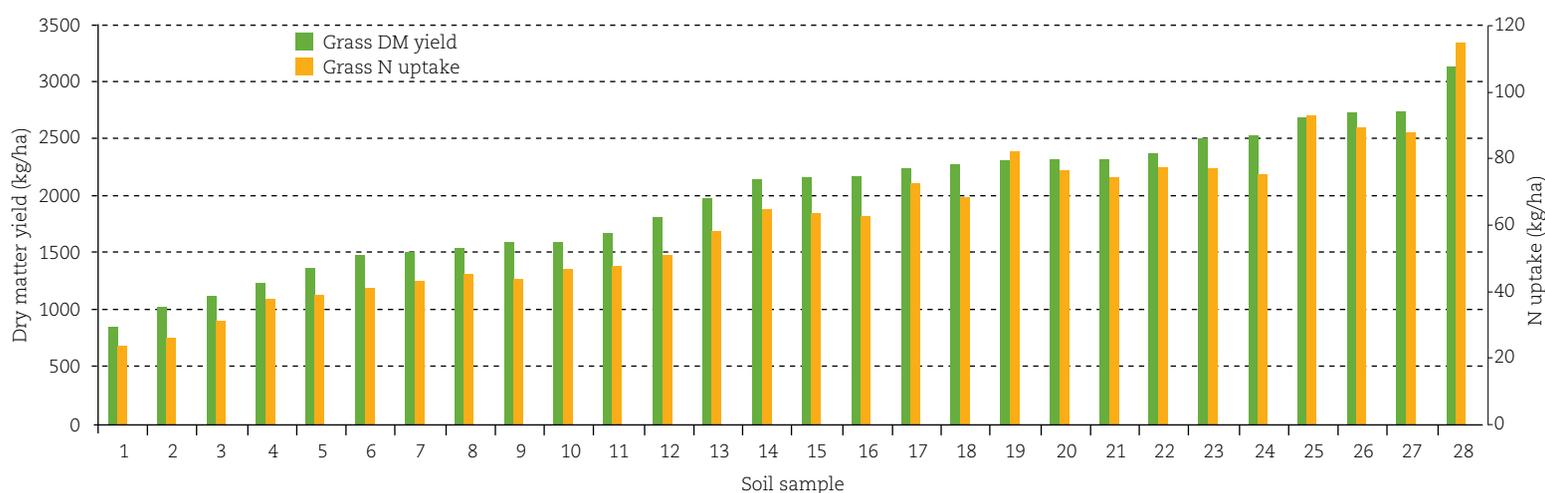


Figure 1: Average grass dry matter yield and nitrogen uptake for 28 Irish grassland soils based on a five week grass growth interval under optimised growth conditions.

Furthermore, of all the chemical tests evaluated, the Illinois soil N test (ISNT), measuring amino sugars and NH_4^+ -N concentrations was found to be the most suitable soil test to predict N_0 in these soils.

Grass N recovery potential between different soils

These laboratory findings were further evaluated in soil microcosm studies where the 28 soil types were potted, seeded with ryegrass (*Lolium perenne* L.), and placed in the controlled environment research facility (see photo). These pots received no N fertilizer applications, but were optimised for phosphorus (P), potassium (K) and sulphur (S), as the aim was to quantify the soil N recovery potential by the grass. Grass harvests and soil samples were taken and analysed at five week growth intervals. Large differences were found between these soils in terms of their grass production potential from soil N reserves as shown in Figure 1. Grass dry matter (DM) yield ranged from 845 to 3,133 kg/ha and was tracked closely by N uptake which ranged from 23 to 114 kg N/ha across these soils over the five week growth period. Under these controlled conditions, the influence of climate on N losses was standardised, therefore isolating the soil type-related effects on N supply. The ISNT, by itself, could not accurately predict grass N uptake and DM yield, as it did not account for residual mineral N in the soil profile. However, when the ISNT was combined with a soil mineral N test (to account for this residual mineral N source), grass N uptake for these soils could be predicted (prediction model $R^2 = 0.72$). This shows that soil N tests can be used to predict grass N responses.

Effects of climate on soil N supply and grass N uptake

In a field situation, climatic variables such as temperature and rainfall influence the N_0 process, soil mineral N levels and grass N uptake from the soil. Considering this, experiments were conducted on contrasting soil types at Teagasc, Moorepark, Co Cork (MP) and Teagasc, Johnstown Castle, Co Wexford (JC), in order to investigate

the potential of these soil N tests to predict soil N recovery by grass under field conditions. There was large N_0 potential at both sites, with the heavier JC soil releasing more N in late summer and early autumn than the lighter MP soil. When sampled in advance of each growing cycle, at the MP site, the combination of ISNT and soil mineral N was able to predict grass N uptake (± 28 kg N/ha) for each grass harvest over the 2012 growing season. However, at the JC site, the high rainfall in the summer of 2012 coupled with the poorer soil drainage capacity resulted in lower grass N utilisation, and consequently the soil N tests did not accurately predict grass N uptake. In such situations where climatic factors negatively affect grass N recovery, these soil N tests will still provide a good estimate of soil N supply potential, and help to calculate the additional N requirement for target grass yield, applied as N fertilizer.

Conclusions

This study shows that Irish soils have a large capacity to supply N for grass growth, but that large variability in quantity and timing of soil N supply exists between different soils. The ISNT test was the best rapid soil N test to predict soil N supply potential under different experimental conditions and scales. Further field comparisons with these soil N tests will be conducted at sites across Ireland to assess their suitability across multiple years and seasons. These soil N tests show the potential to account for soil N supply when making N fertilizer recommendations for grassland soils. This will lead to better soil N utilisation and increased N fertilizer use efficiency on farms, leading to associated financial and environmental benefits.

Funding was provided by the Department of Agriculture, Food and Marine, through the Agricultural Catchments Programme.

Power ultrasound for curing pork

Ciara Mc Donnell was awarded ‘Best Presentation on Food’ for her PhD on the use of power ultrasound for accelerating the curing of pork at the Teagasc Walsh Fellowships seminar.



Meat curing is the most ancient food preservation technique dating back to 3000 BC. Curing techniques have evolved into different methods such as wet-curing, injection-curing and dry-curing. Salt (NaCl) is the most important of all cure ingredients as it improves shelf-life, flavour, juiciness and tenderness. Regardless of the method used to cure meat, diffusion of NaCl into the complex meat matrix is slow; taking up to two days per kilogram for traditionally-cured products. While injection-curing is fast, it produces lower quality cured pork products. The meat curing industry would benefit from a novel processing technology that could produce high-quality products under accelerated processing conditions.

Power ultrasound

Power ultrasound is a technology that can lead to increased mass transfer through the mechanism of cavitation. Cavitation is the implosion of microscopic gas bubbles due to pressure fluctuations at a very high frequency (>20 kHz). This violent bubble implosion could create microscopic channels in the meat matrix for increased diffusion and improved quality. Increased mass transfer through the application of ultrasound has already been proven in food matrices such as cheese, apples and strawberries; however research on meat is lacking. The technology is certainly viable for industrial application. It was first used in the 1960s for cleaning and has since been applied industrially for homogenisation, emulsification and degassing. As an added advantage, the technology works with excellent energy efficiency (>85%).

Reducing curing time

A research collaboration between Teagasc Food Research Centre Ashtown and University College Dublin has assessed the potential for ultrasound to reduce meat curing time. Salt and moisture uptake acted as an indicator for accelerated processing. Quality attributes such as pH, colour, texture profile analysis, cook loss and water holding capacity, were

also analysed. Protein denaturation and hydration were assessed by differential scanning calorimetry (DSC) and low-field nuclear magnetic resonance (LF-NMR), respectively. Samples were treated with ultrasound intensities of 50, 75 or 100 W/cm² for 10, 25 or 40 minutes in a specially designed treatment vessel with an ultrasound probe (550 W). There was a tendency for NaCl content to increase with power input (intensity × time). Moisture content was significantly increased by 100 W/cm² for 10 or 25 minutes. There was no effect on the pH or the total colour difference of samples. Ultrasound caused a significant reduction in cohesiveness and gumminess of samples, however hardness and chewiness are considered to be more important sensory traits for ham and these were not affected. Myosin denaturation (indicated by DSC) occurred in samples treated with the highest power output (100 W/cm² for 40 minutes) but this effect was not evident at a depth greater than 2 mm from the surface. Myosin is the most important protein for water-binding within the meat fibre, thereby affecting juiciness, so its denaturation should be avoided. However, as the denaturation only occurred on the surface of the samples, no changes in water holding capacity, water mobility or distribution were evident.

To date, results indicate that power ultrasound can reduce processing times by accelerating NaCl diffusion, without any detrimental impact on the end-product. Work is currently underway on a pilot-scale production of sonicated hams for sensory trials.

Funding for this research was provided by the Food Research Institutional Measure of the Department of Agriculture, Food and the Marine.



Image courtesy of Bord Bia.

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Bovine lactoferrin potential as bioactive ingredient



Changes in the glycosylation of bovine milk lactoferrin over the course of lactation can influence its value as a functional food ingredient. Noelle O'Riordan received an award for best three-minute presentation on this topic at the annual Teagasc Walsh Fellowships seminar.



Lactoferrin (LF) is a bovine whey glycoprotein that can have up to five glycan (sugar) chains attached. Found in mammalian milk, it has a range of biological activities including anti-microbial, prebiotic and immuno-regulatory properties; and the glycan chains have been shown to play a role in many of these bioactivities. Our group aims to characterise changes which occur in the glycan structures of bovine LF over the lactation period, as glycosylation changes may result in changes in the biological activity of the protein.



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Glycoprofiling

LF was isolated from the milk of three cows over the first three months of lactation and its glycosylation was analysed using lectin arrays. Lectins are proteins that recognise and bind specific glycan structures and lectin arrays consist of a panel of lectins with varying specificities, which are immobilised on a chip. A fluorescently-labelled glycan or glyco-conjugate, in this case bovine LF, is incubated with the array and if a specific saccharide structure is present, a positive interaction will be observed for its corresponding lectin. The array can then be scanned and an example of the generated image is seen in Figure 1. The fluorescent intensity associated with each spot, or lectin, can then be extrapolated and graphed, resulting in the generation of a glycoprofile for LF from each timepoint over lactation.

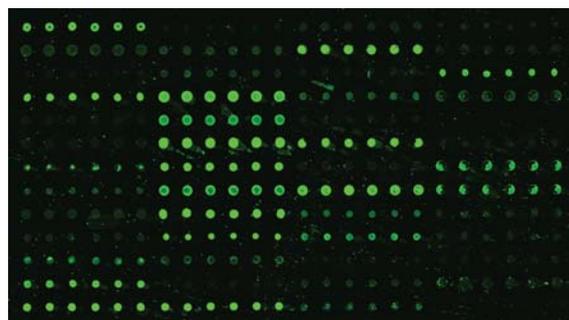


Figure 1: Lectin array imaged following incubation with fluorescently labelled bovine lactoferrin. Six replicates of 43 lectins, selected on the basis of carbohydrate-binding preference, and experimental controls are spotted in each array.

Bioactivity of LF

When the glycoprofiles of LF over lactation were examined, three distinct phases of glycosylation were observed, corresponding to colostrum, transitional milk and mature milk production. Colostrum samples bound to the highest number of lectins and to a greater extent than later lactation timepoints. This implies colostrum samples have a greater variety of glycan structures present, which in turn suggests a higher level of associated bioactivity. This glycan complexity protects the LF protein from proteolytic digestion; ensuring delivery of intact LF to the lower GI tract. This complexity is lost by Day 5 of lactation. However, a relatively high level of sialic acid, which has been shown to possess prebiotic and anti-microbial activity, is still present at this stage of lactation and into mature milk, emphasising the importance of sialylated glycans for the protection of the newborn calf. The most striking feature of the mature LF glycoprofile is the prevalence of oligomannose-type glycans, which contain repeating units of mannose residues and have been shown to be anti-infective against pathogens.

LF as bioactive ingredient

A large number of companies in Ireland and Europe produce pure LF powders or use LF as an ingredient in their products, such as infant formulas, health supplements, protein mixtures and, more recently, cosmetic creams for the treatment of acne. However, these companies use mature bovine milk as their LF source. This study demonstrates that colostrum LF has a more complex glycoprofile and therefore has increased biological potential. While bovine colostrum is not as readily available as mature bovine milk, it does represent a higher value LF ingredient, which could be utilised in more functionally specific products, e.g., infant formulas for babies suffering from an immune disorder; as an immune supplement during and following infection; or as a prebiotic supplement for patients who experience perturbations to their intestinal microflora following treatment with medications such as broad-spectrum antibiotics. This study highlights the potential of colostrum LF for use in such products.

This work was supported by the Teagasc Walsh Fellowship Programme, Science Foundation Ireland, under Grant No. 08/SRC/B1393 and the Alimentary Glycoscience Research Cluster (AGRC).

Orange flour for gluten-free bread



Milling of orange pomace to orange flour.



A by-product from the Irish fruit processing industry as a novel ingredient in gluten-free bread won the award for best poster at the Teagasc Walsh Fellowships seminar.



During the processing of fruit and vegetables one third is discarded as 'waste'. The waste or by-product can be described as the core, pips and peel of the fruit or vegetable. This waste can be costly for the manufacturer to dispose of and it may also have hazardous effects on the environment. Research has shown that a high quantity of nutrients, i.e., dietary fibre and bio-actives are present in these by-products, thus the full potential of the fruit or vegetable is not fulfilled. For example, orange pomace (OP), a by-product from the smoothie and juice industry, has proven to have good nutritional attributes; it is low in fat (2% dry matter) and high in dietary fibre (40% dry matter) and has the potential to be used as a food ingredient.



Coeliac disease

Presently in Ireland, approximately one in a hundred people suffer from coeliac disease. Coeliac disease can be explained as an autoimmune reaction to the prolamin fraction of the gluten protein, which causes damage to the villi in the small intestine. The only treatment for Coeliac disease is lifelong avoidance of foods containing wheat, barley, spelt, rye and some oats. Many gluten-free products available on the market are calorie dense, lacking in flavour, mouthfeel and nutrients, and are costly to buy.

The main objectives of this study were:

- To demonstrate a potentially new application for an Irish fruit by-product, in this case OP
- To assess the dough rheological properties of an optimised gluten-free formulation containing OP
- To assess the baking, sensory and micro-structural properties of gluten-free bread enhanced with an OP
- To assess the dietary fibre content of the optimised bread formulation

Gluten-free formulations

Developing gluten-free formulations can be challenging for the cereal technologist, as the structure-building protein (i.e. gluten) is absent. In the present study, a response surface design was created to statistically calculate the optimal level of OP addition, water addition and ideal proofing time to produce an optimal bread formulation. This study investigated the effects of these three factors in different combinations on bread parameters such as loaf volume, crumb structure, crumb colour, texture, moisture content, nutritional and sensory properties. The final bread contained the following optimised factors: 5.5% OP (flour weight basis), 94.6% water (fwb) and a proofing time of 49 minutes, creating bread with favourable baking characteristics. With the addition of 5.5% OP, the dietary fibre content of the bread was significantly increased from 2g/100g to 4g/100g. Sensory panellists scored the bread favourably with respect to appearance, flavour, texture and overall acceptability.

Rheological analysis (mixing properties), starch-pasting properties (effect of heat on the dough) and confocal microscopy investigated the impact of OP addition on the different aspects of the gluten-free dough. Rheological results showed how the inclusion of OP increased the consistency and viscosity of the dough. Starch pasting properties are related to starch retrogradation and crumb staling; higher pasting results indicate a higher rate of staling in the end product. Lower starch pasting results were received for OP-containing doughs when compared to the control, indicating that the OP interfered with the starch when heated and thus slowed the rate of staling. Images from confocal laser scanning microscope support these findings, illustrating OP/starch complexes in the dough system.

Potential for gluten-free products

The inclusion of OP as a novel structure-building and nutritious ingredient in a gluten-free formulation was illustrated in this study. Using response surface methodology as a tool, successfully created bread with favourable baking characteristics and enhanced dietary fibre. OP proved to be a viable, low cost food by-product for improving the physical and nutritional characteristics of gluten-free breads. The addition of this ingredient is not limited to gluten-free bread; it has potential to be used in both gluten-containing and gluten-free breads and confectionary.

Acknowledgements

The research was funded by the Department of Agriculture, Food and the Marine under the Food Institutional Research Measure (FIRM). We would like to acknowledge Teagasc National Food Imaging Centre at Moorepark, Fermoy, Co Cork.

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Comparative transformation of potato leaf (upper) and tuber (lower) tissues with OV14 (left column) and *A. tumefaciens* (right column), with untreated potato leaf and tuber tissue in the centre. Presence/absence of blue stained tissues indicate the success/failure of the bacteria to successfully achieve genetic transformation.

A method for the transformation of plant cells

Teagasc Technology Transfer Office details below a significant novel technology developed in collaboration with University College Dublin, relating to methods for transforming plant cells, which may have significant implications in both research and commercialisation opportunities within the global ag-biotech industry.



Teagasc and University College Dublin (UCD) jointly developed and continue to refine and improve a novel plant transformation technology relevant to the global ag-biotech research and industry. We are seeking partners within the ag-biotech industry to partner us in further developing this novel method of transforming plant cells for use on specific crops with a view to licensing in the future for commercialisation purposes.



Background

Existing Intellectual Property Rights in crop research restrict the use of the primary technique for the generation of genetically modified (GM or 'biotech') crops. This technique utilises the bacteria *Agrobacterium tumefaciens* in a process termed *Agrobacterium tumefaciens*-mediated transformation (ATMT). While ATMT is used worldwide by thousands of scientists in public-sector agencies and institutions, private industries and universities, to the end-user of ATMT, adopting the technology for a specific task is problematic due to current patent restrictions. Teagasc and UCD have developed a novel method of transforming plant cells which aims to bypass existing restrictions. Experimental trials have to date proven that this technology produces stable transformants at a rate equivalent to current systems when applied to potato, tobacco and *Arabidopsis* plants and work continues on other crop species.

Solution

We have identified a novel bacterium (OV14) that successfully transfers single/multiple gene(s) of interest into plant cells at rates equivalent to standard ATMT. By directly substituting OV14 for *Agrobacterium* in a standard ATMT transformation protocol, we have confirmed stable transgene integration and expression in the model species *Arabidopsis* and two crop species (potato and tobacco) at rates equivalent to that achieved with ATMT. OV14 is genetically distinct from *Agrobacterium* and, as such, circumvents existing transformation patents on dicotyledonous species, which is key in an area monopolised by large multinational ag-biotech companies.

Competitive advantage

- OV14 is genetically distinct from *Agrobacterium* and as such circumvents existing transformation patents on plant species.
- OV14 does not require challenging conditions or processes for its growth and can be integrated into existing ATMT-based protocols with no additional optimisations required.
- OV14 will willingly uptake and harbour plasmids of varying size through multiple generations.

Opportunity

This represents an opportunity for institutes and industry working on the genetic improvement of crop species for agronomic, nutraceutical and/or pharmaceutical purposes. It would allow public sector and small-to-medium enterprises to acquire a novel transformation platform for their gene discovery studies. As some validation and optimisation is still required, we are currently seeking partners for such commercialisation with a view to licensing.

Intellectual property status

A patent application has been filed by Teagasc/UCD and is in examination stages in a number of territories. PCT application was filed 23/12/2010 with Application number PCT/EP2010/070681, claiming priority from European Patent Application no. 09180700.8 filed on 23/12/2009, and national phase entered in June 2012.

Further Information

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This research was supported by Teagasc funding, including the Teagasc Walsh Fellowships scheme, in collaboration with UCD.

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Renewed emphasis on agri-food research funding



Dr John Dardis outlines recent developments in the USA that have put agri-food research funding back in the spotlight.

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It's always easy convincing those within the sector of the importance of agri-food research. What is more challenging, particularly with tight purse strings, is selling that importance to those outside the agri-food area. With further food price shocks keeping the political eye fixed on food production, 2012 saw a number of very significant endorsements in the USA. The evidence of the return on investment is striking. One only needs to look at the 2012 cropping year, where the USA faced its worst drought in 60 years yet the corn and soy crops, while obviously being hit, performed remarkably well; or, the continued fall-off in cattle numbers, yet USA meat production continues to climb; or the massive change in conservation practices that have transformed the 'dust bowl'. Let me tell the story of the 2012 developments Stateside that have caught the attention. I suspect they will be referenced many times in grant applications!

Gates Foundation

It's always good to have a cheerleader with clout, and they don't come much bigger than Bill Gates, co-founder of Microsoft and philanthropist. Early in 2012, Bill Gates issued his Annual Letter from the Bill and Melinda Gates Foundation calling for more funding for agricultural research. The letter began by highlighting the importance of agricultural innovation, with Mr Gates expressing concern on funding given the economic and political climate.

In the letter, Mr Gates talks of the "shocking – not to mention short-sighted and potentially dangerous" amount of funding that is spent on agricultural research. Mr Gates draws a direct link between

the shortage of research funds and the increase in prevalence of plant diseases. He also raises crop diversity: indeed, he references the potato famine in Ireland as an example of what can happen without varietal diversity. However, he went on to say that there "are reasons to believe that the chronic underfunding of research in agriculture is starting to change", with particular emphasis on "public-private partnerships" and the role of "key partners" from rapidly growing countries like Brazil and China who bring resources and experience. The Gates Foundation has entered model agreements to work with both countries.

Public and/or private?

In December, the journal *Science* published a paper by Fuglie *et al.* (2012) on the relationship between public and private investment in R&D and their importance in agricultural growth. The analysis of the private funding element is a particularly timely input to discussions on global food production, and more locally – given the significant pressure on all public research coffers and the fiscal cliff – the United States Department of Agriculture's (USDA) own research system. There are those that argue that the public research system should be cut further and allow private research to continue to fill the void. The paper clearly shows the downfalls in such an approach. While world inflation-adjusted, R&D spending increased 43% between 1994 and 2010, all the growth occurred in the crops area (see Figure 1). In both crop seed and animal breeding, biotechnology research has been an important driver of consolidation in these industries.

About half of all private investment in food and agriculture research has been devoted to food manufacturing and not toward input industries and other areas that directly increase agricultural production.

Roundup ... at the Fort Keogh Livestock and Range Research Station in southeastern Montana. At this station, one of the largest in the world of its kind, researchers help to ensure a plentiful supply of meat while protecting the rangeland environment. Photo by Jack Dykinga. Image courtesy of USDA Agricultural Research Service photo library.



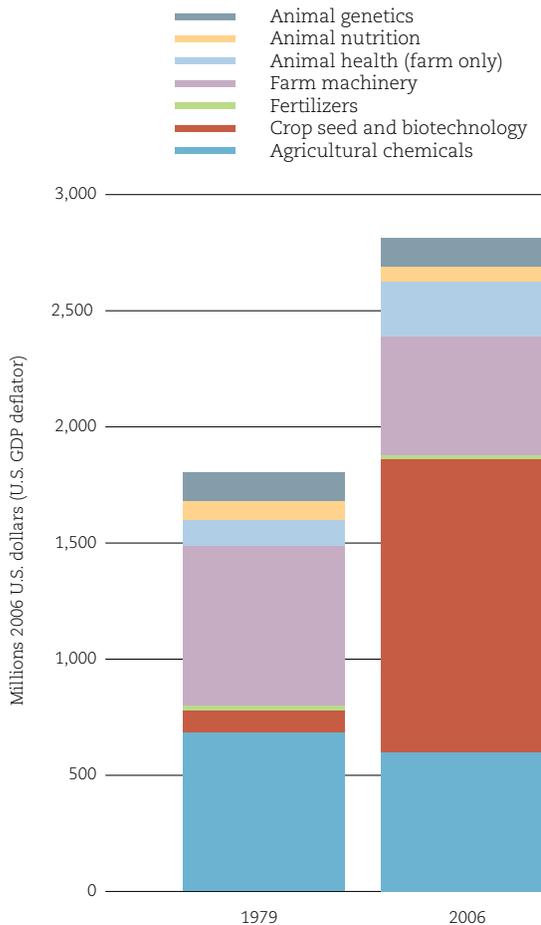


Figure 1: Private agricultural input research in the United States, 1979 and 2006 (from Fuglie *et al.*, 2012).

President Obama's Council of Advisors

In December, to add to the momentum, the President's Council of Advisors on Science and Technology (PCAST) issued a report on Agricultural Preparedness and the Agriculture Research Enterprise.

The impetus for this analysis has been driven by Dr Catherine Woteki (USDA Chief Scientist). Faced with budgetary pressure, she took a leadership role, supported by USDA Secretary Tom Vilsack. They asked PCAST to identify and recommend ways to optimise innovative public sector agricultural research, stimulate training the workforce, and ensure that the USA maintains its leadership in agriculture.

The report concludes that the USA agriculture research system is not prepared to face the 21st century challenges for two reasons:

- The proportion of federal funding for agricultural research through competitive mechanisms is far below the proportion in other agencies.
- The research system overlaps with private funding and leaves other areas unaddressed.

The bottom line is that PCAST recommends the USA increase agricultural research investment by \$700m per year. The report presents its recommendations as a means to tackle the major challenges of new pests, pathogens and invasive species, water use, reduced environmental footprint, climate change, bioenergy, safe and nutritious food, and global food demand. The following recommendations are presented in the report, which emphasise new refocused investments in agricultural research by:

Adjusting the focus of USDA funding towards competitive grants

It's not the first time this has been recommended, and the establishment of the National Institute for Food and Agriculture in 2004 was directly charged with this role, but its competitive

component only accounts for less than 10% of USDA research funding. The report calls for a doubling of the current competitive award from \$265m to \$500m.

Increasing funding for basic science relevant to agriculture

Perhaps a key take-home message to research funders is that PCAST calls on National Science Foundation (NSF) to double its budget for basic science relevant to agriculture from \$120m to \$250m, as well as increasing the USDA/National Institute of Food and Agriculture budget for extramural funding from \$265m to \$500m.

Expansion of competitive fellowship programme

USDA, in collaboration with NSF, expands a national competitive fellowship programme for graduate students and post-doctoral researchers to ensure a high calibre of USA agricultural scientists.

Infrastructure investments

USDA expands its programme of competitive awards for new infrastructure investments in agricultural research, with an emphasis on specialisation and consolidation to avoid redundancies.

Creation of institutes

New federal investment of \$150m per year to create six institutes, at a funding level of \$25m per year, to tackle the major challenges. This should be coordinated by USDA, but in collaboration with NSF, Department of Energy and National Institutes of Health.

Review of Federal regulatory policy

In order to ensure more effective and efficient technology transfer, the report calls for an internal review of federal regulatory policy for agriculture to tackle the complex regulatory environment that delays or prevents new intellectual capital from being commercialised.

Implementation

Set up an implementation committee to act on these recommendations.

The report acknowledges that there is significant budgetary pressure; but that the \$700m suggested increase in funding is minimal when pitched against the USA federal spend of \$100bn on R&D. It's going to be a significant challenge to see this process through, but President Obama's re-election gives consistency to the process.

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This article was published with the approval of the Department of Agriculture, Food and the Marine.



Lessons for effective and efficient knowledge transfer

The importance of efficient and effective innovation support for industries as diverse and technically challenging as primary agriculture was highlighted at the Best Practice in Knowledge Transfer conference held in the Aviva stadium last November.



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The context of the conference was set by Sean Kelly MEP who confirmed the EU's commitment for new and ongoing innovation support. Teagasc and Ireland have a huge opportunity to be part of new initiatives in this area. Inge Van Oost of the EU Commission (DG Agri) outlined the commitment of the EU to supporting innovation in agriculture. The post 2013 reform of CAP will link two significant elements which will address the technology gaps between research and farm practice, through support for improved knowledge transfer:

- Support for an expanded Farm Advisory System (FAS). This will address productivity and efficiency in addition to advice on cross compliance
- Support for innovative actions that support improved transfer of new technology and knowledge from research into practice delivering a more sustainable and competitive agriculture. This action will be achieved through a new framework programme and innovation policy called 'Horizon 2020'. This support will take the form of a European Innovation Partnership (EIP) for agricultural productivity and sustainability.

The EU, she said, is determined to commit some funding under pillar 2 of the CAP to establish operation groups. The EIP network will support cost-effective applied research and knowledge transfer initiatives.

Lesson 1

Identify technology gaps

Professor Gerry Boyle, Teagasc Director, identified some of the knowledge gaps that exist in Irish agriculture. These gaps are the indicators of the success of Teagasc. The closing of gaps for a number of different, new technologies and codes of practice differ in the ease of adoption. Therefore, experience in how to achieve practice adoption that is lasting, which closes these gaps, is important.

Lesson 2

Networks of expertise

The integration of research, advisory and training programmes is important in enabling Teagasc achieve its mandate. A detailed network analysis of the Irish Agriculture Knowledge and Innovation System (AKIS) showed that there are some strong and some weak connections between many of the key stakeholders. The knowledge network has improved through joint programmes, formal alliances and Memorandums of Understanding (MOU), much more work can be done to improve the network of agricultural knowledge exchange.

Lesson 3

Optimising resource inputs

Co-ordinated, holistic programmes ensuring that resource inputs are optimised to get new technologies adopted by farmers. Cees Leeuwis, Wageningen University, stated that the innovation challenge is a multi stakeholder process and should be analysed as a whole, it may involve new products, new processes, new social systems and organisation change. In looking at the role of public or private extension services Cees promoted the need for a new style innovation intermediary, where extension services personnel are co-coordinators and facilitators of knowledge exchange. The programmes need to demonstrate value added at farm, industry and



Professor Gerry Boyle, Director, Teagasc; Inge Van Oost, DG Agri, EU Commission; Cees Leeuwis, Wageningen University; and Frank O'Mahony, Macra na Feirme representative, Teagasc Authority.

national level. The targeting of advisory programmes, at the wider population of rural professionals, increases the efficiency of knowledge transfer and stimulates change amongst farmers. The needs of the major stakeholders must be met in order to lead change and innovation, the options must be real, there must be confidence created and the knowledge gap must be narrowed. The achievement of this requires capacity building through collective learning and high levels of farmer/user ownership. The latter is important in achieving an obligation to listen and to act regardless of the farmers' traditional beliefs.

Lesson 4 Stakeholder buy-in

Several speakers highlighted the importance of stakeholder involvement in all areas of innovation support. The commitment of all stakeholders is important at all stages of the innovation support process; this commitment can be measured by their contribution to funding, direct involvement and participation in activities.

One workshop on the day suggested that these joint programme arrangements must have clear attainable goals, a holistic approach, no magic solutions and use private funding to gain private sector support. The alignment of goals at the outset is most important. Some joint programmes have been in place now for over 20 years and have survived several renewals. The ability of Teagasc to achieve its mandate in future will depend on collaboration with other organisations and individual service providers.

Lesson 5 Adviser-farmer relationship

This relationship must be built on independence, quality of service and trust. Stephen Morrison, a young, drystock farmer from Co. Kildare, described the complexity of making business decisions on his farm and the value of independent advice. He valued highly his own participation in a local Teagasc discussion group and the one-on-one meetings with his adviser. He emphasised the individuality of his own farm, farm system, family situation and community. He felt that general advice was of little use to him. Combinations of independent one-on-one contact with the adviser and the network of other farmers in his discussion group provide a valuable developmental support to him.

Lesson 6 Applied research role

The shift from individual component advice to more integrated farm systems advice is important, this must be contextualised, with real and lasting benefits. The use of demonstration and monitor farms to demonstrate the sustained benefit of new systems and technologies was highlighted by the Teagasc/*Irish Farmers Journal* BETTER beef programme, which combines private industry investment, stakeholder input and regular media reporting to support intensive advisory activity, resulting in significant impact on profitability of the farmers involved.

Lesson 7 Education of professionals

Tim Mackle, DairyNZ, said that targeting of advisory programmes at the wider population of rural professional increases the efficiency of knowledge transfer and stimulates change amongst farmers.

Facilitation and ICT are huge areas of importance for future advisers, while other areas, such as conflict resolution and filling advocacy roles were also important.

Ongoing research is required in understanding the effectiveness of innovation support and the communication challenge of keeping up to speed with changes in technology.

Lesson 8 Facilitation culture

The development of a culture of facilitating more learning from other farmers through the discussion group model. With less advisory resources now, on average 40% of Teagasc dairy adviser time is deployed to this method currently. The role of big brand campaigns with multiple actors was also important in getting the attention of the farmer.

Lesson 9 Farmer data

The use of new ICT tools provide specific data and benchmarking of financial and physical performance was important in the farm's development and the basis of better advice and decision making. There are opportunities for the automated flow of data to the farmer and adviser in easy-to-use report formats.

Lesson 10 Practical, relevant and easy to use

Advisers face the challenge of working in a complex knowledge system, they deal with complex technologies and a diversity of stakeholders and farmers but must consistently present information which is practical, relevant and easy to implement.

Reference and further reading

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Food security -small steps on big issues

Following the launch of the Teagasc – RDS Lecture Series on ‘Grand Challenges for Global Agriculture and Food’, Teagasc is piloting a new initiative on research and knowledge transfer for international food security. In this article Teagasc’s new Food Security Committee lays out its plans.

Agriculture and food security have returned to the centre of the political agendas on development. In 2011, for the first time, the agriculture ministers of the G20 countries agreed to work together to tackle food insecurity. Ireland is not immune to the impacts of possible disruptions to food trade and future supplies of essential inputs such as phosphate and the linked environmental challenges. Neither can we abdicate our responsibilities as a nation to support the food security needs of poorer countries unable to raise their own food output.

New dynamics on food security also provide opportunities for Ireland to meet the need for food elsewhere in the world. By 2050, the FAO estimate that the world will need to produce up to 70% more food each year in order to feed a predicted population of more than 9 billion. Increasing income in the emerging economies is also leading to changing patterns of food consumption. This growth in global food markets and the changing nature of food consumption open up major opportunities for Irish food products. This is reflected by a growing interest from agribusinesses in setting up partnerships in developing countries and by the Food Harvest 2020 strategy, which specifies a vision on the “internationalisation of Irish agri-food expertise”.

In response to these policy drivers, the Irish

Government prioritised the “eradication of hunger” as its primary objective in overseas development, as set out in the report by the Irish Aid Hunger Task Force.

From yield potential to food security

Fifty years of agricultural R&D has resulted in a doubling of the yield potential of most agricultural commodities. The degree of success of these efforts can be interpreted from two opposing viewpoints: FAO statistics show that the total number of people suffering from malnutrition has remained almost constant over the last 20 years. In the face of a growing world population, this represents a reduction in the percentage of undernourished people from 20% in 1991 to 13% by 2006. At the same time, these same statistics show that global efforts on food security will need to be accelerated to meet the basic needs for a further 800 million people who currently remain undernourished.

At the second Teagasc-RDS Lecture, Dr Dominique van der Mensbrugge (FAO) argued that sufficient technologies and natural resources are available to meet the 1996 World Summit target of halving undernourishment levels to below 405 million people (see article on p22). However, increasing primary production is only part of the wider solution that is needed. In many developing regions, achieving food security is not necessarily hampered by yield potential, but rather by gaping holes in the value-chain from farm to fork, and by the lack of purchasing power of consumers. Therefore, the contemporary approach to food security focuses on integration along the entire value chain. There is no single organisation that has the resources or expertise to take sole responsibility of such an integrated approach – instead, this can only be achieved through partnerships.



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Food security requires more than increased crop yield. In many places, excellent crops are produced but not consumed, as a result of insufficient processing and marketing facilities. Food security requires all aspects of the value chain to be addressed at the same time.

Teagasc food security initiative

Teagasc is uniquely placed to contribute to such partnerships. The knowledge deficit of many smallholder farmers is a direct result of the disconnect between research and extension services, which has emerged not only in developing regions, but also in most developed countries. In fact, Ireland is one of the few remaining countries with integrated research, education and advisory services. In this light, it is not surprising that Teagasc is now increasingly approached by its sister organisations and governments around the world for guidance on the resurrection of these links, and to assist in the translation of yield potential into actual yield increases achieved by farmers.

Teagasc and the Department of Agriculture, Food and the Marine (DAFM) are taking a leadership role in international fora on global food security, such as the EU Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI). Now is an opportune time to ground and complement these high-level discussions with frontline initiatives that will make a tangible difference to farmers.

For this reason, Teagasc has launched a food security initiative, in which it will strategically lend its knowledge and expertise to development partnerships that focus on achieving food security. In a time of significant resource constraints, we will have to be selective and engage only with partnerships where Teagasc can bring maximum added-value. Typically, these partnerships will be characterised by five criteria:

- alignment with Teagasc's own Statement of Strategy and DAFM's report on 'Internationalisation of Irish Agri-Food Enterprise';
- focused on assisting developing countries in developing their own indigenous capacity in research and knowledge transfer;
- based on partnership – in which Teagasc contributes its own specific expertise;
- alignment with Irish Aid's hunger agenda; and
- focused on Irish Aid's nine programme countries.

Engagement with partnerships will be coordinated by Teagasc's new Food Security Committee. A pilot study on sustainable seed potato production systems in Ethiopia commenced in 2012: progress and first results from this study will be reported on in *TRResearch*, later this year.

Details on Teagasc's Lecture Series 'Grand Challenges for Global Agriculture and Food' are available from: www.teagasc.ie/events/rds-lecture-series/index.asp

Follow @RogierSchulte for regular updates on Teagasc's new food security initiative.

Food security workshop

By Dr Cathal O'Donoghue

Teagasc and UCD, as part of their Agricultural Research, Education and Innovation Partnership, hosted a workshop on November 27 at the RDS focusing on Food Security. The workshop featured presentations from international speakers from the University of Geneva, Global Forum on Agricultural Research and the Food and Agriculture Organisation of the UN (FAO). The presentations were followed by a round table discussion which focused on:

Why get involved in the development agenda?

- Utilise our expertise on food development to improve food security and nutrition.
- International policy and engagement is becoming more important for Irish industry, particularly in the area of market access and climate change.
- Ireland needs to be part of global food security consortia as it is relevant for our own national interest, but to participate, we need to have direct experience.

What challenges exist?

- Agricultural extension in Africa faces challenges in terms of capacity constraints.
- Poorly functioning agri-food supply chains.
- Capacity gaps in the area of strategic planning and analysis.

What do we have to offer?

- Irish institutions have significant experience of R&D across the food supply chain.
- A well functioning extension service with experience of linking research, extension and education.
- The central role farmers/food companies play in research prioritisation.
- A track record of effective strategic planning, policy and foresight analysis.

How do we get involved?

- Maximise the effectiveness of the resources, building upon existing partnerships between institutions within Ireland, while building on international initiatives and linking with national institutes in developing countries.
- Involving the whole supply chain, particularly the agribusiness sector.
- Focus on technologies and methods that have the greatest ease of uptake.

Feature

Health is a vital resource for lifestyle and farm business operation.



Health of farmers in Ireland

A recent survey of Irish farmers has highlighted important issues surrounding occupational health.

Why investigate health problems among Irish farmers?

Many significant health factors face those working on farms, compared to other work sectors. Farmers work long hours, work in all types of weather conditions, use many different types of machinery and chemicals, work with unpredictable animals and carry out a wide range of both mental and physical activities that may affect health. International studies have reported occupational health among farmers as one of the worst amongst all occupations. However, in Ireland very little is known about Irish farmer health as only a few research studies have previously investigated this topic. One of these studies was a survey of health and safety on Irish farms, which found that farm-related ill health problems occurred on over 11% of the respondent farms; and, in three-quarters of the cases, the ill-health problem was described as moderate to severe (Finnegan et al., 2003). Research has also been published regarding disability among farmers and found that almost 5.9% (n=6,611) of Irish farm operators reported disability, primarily caused through illness/disease with arthritis (31.4%), back problems (17%), and heart circulatory problems (12.5%) being the most frequent illness/disease reported (Whelan et al., 2009). This research also identified that the highest prevalence of disability was found among cattle farms (7.1%), with the lowest

levels found among tillage (1.4%) and dairy farms (4.1%). Furthermore, there is a link between health and farm income. Family farm income was lower (€123 per hectare) on disability-experiencing farms relative to farms that did not experience disability (Whelan et al., 2009). Recent research has indicated that, as a consequence of the health issues experienced, farm owners are 5.1 times and agriculture workers 7.4 times more likely to die compared to salaried employees, with circulatory diseases, cancers, and injuries and poisonings being reported as main causes of mortality (Smyth et al., 2012). Poor health has also been linked with increased injury risk in several international studies.

Why this research?

In 2008, as part of the Workplace Health and Well-Being Strategy, the HSA placed a priority on achieving improvements in the level of occupational health at all workplaces, including farmers. This strategy was to raise awareness of the importance of the health and well-being of the working age population and to recommend actions to improve worker health. Among the follow-on initiatives was a joint research initiative funded by Teagasc and the HSA that sponsored a four-year Walsh Fellowship PhD programme focusing on Occupational Health Problems among Farmers in Ireland. This initiative also involved collaboration between University College Dublin (UCD) School of Physiotherapy and UCD School of Agriculture and Food Science. One of the key tasks associated with this research was a survey of 600 farmers. The results are summarised below.



Table 1. Health problems reported by Irish farmers.

Health Problem	All Farmers (n=600)	Farmers with health problem (n=363)
	Number (%)	Number (%)
Musculoskeletal disorders	325 (54)	325 (90)
Respiratory problems	26 (4.3)	26 (7)
Digestive problems	20 (3.8)	20 (6)
Disease of the ear	18 (3)	18 (5)
Mental health disorders	16 (3.1)	16 (4)
Diabetes mellitus	10 (1.7)	10 (3)
Genitourinary problems	8 (1.3)	8 (2)
Circulatory problems	8 (1.3)	8 (2)
Blood pressure/cholesterol	6 (1)	6 (2)
Disease of nervous system	4 (0.6)	4 (1)
Other cancers	4 (0.6)	4 (1)
Other health problems	3 (0.6)	3 (1)
Skin cancers	2 (0.3)	2 (1)
Animal disease (zoonosis)	2 (0.3)	2 (1)

Farmer health survey

A questionnaire survey of Irish farmers was conducted on 600 farmers, with 100 farmers from each of the six main farm enterprise systems namely: dairy, dairy and other, cattle rearing, other cattle systems, mainly sheep and tillage. The questionnaire was distributed at Teagasc courses, farm walks and events. Data were analysed using descriptive statistics, chi square tests and logistic regression models.

Survey findings

Of the respondents, 363 (61%) farmers had experienced some significant health problem in the previous year (Table 1). The study reported different levels of health problems than those reported by the general Irish population through the CSO. In the general population hypertension (11%) and high cholesterol (10%) were reported at much higher levels compared to those reported here for Irish farmers (2%). Given these higher levels and the fact that cardiovascular disorders was identified by the World Health Organisation as the number one cause of death globally, perhaps there is a lack of awareness of certain health conditions among Irish farmers. This view is supported by the 'Farmers have Hearts' project evaluation conducted by the Health Service Executive (Evans et al., 2009), which reported that 56% of farmers evaluated by a health professional were classified as having mild, moderate or severe hypertension. Levels of mental health disorders reported by Irish farmers were also lower in comparison to general population findings (14.3%).

Although 61% of Irish farmers reported experiencing a significant health problem, the majority of farmers' (80%) rated their health as 'good' (40%) or 'very good' (40%) where 'excellent', 'fair' and 'poor' were 17%, 2% and 1%, respectively. Self-rating of 'poor' health was greater in farmers aged 60 years of age or older, with those who had farmed for less than 40 years and were also significantly higher in sheep farmers compared to farmers in the other enterprises. Nearly three quarters of the farmers (73%) in the current study had visited a health professional at least once in the previous twelve months and this is comparable to Central Statistics Office Irish general population findings where 88% consulted with a health service at

least once in the same period. The research also found lower levels of regular physical activity participation (3-4 times a week or more) among farmers (30%) compared to the general population findings (55%). Due to the physical nature of farm work farmers may feel there is no need to participate in other exercise; however, with increasing mechanisation on farms this may have reduced the levels of physical activity achieved through farm work. Unless this is measured further, it is difficult to come to a conclusion on whether farmers are undergoing recommended levels of the correct type of physical activity required for good health.

Future work

Given the apparent lack of awareness of certain health issues such as cholesterol, blood pressure and lower levels of participation in physical activities, health promotion strategies for farmers that target common health problems like cardiovascular risk factors are required. With the current economic situation, especially as family farm income has been found to be lower on disability-experiencing farms relative to farms that did not experience disability (Whelan et al., 2009), it is important to promote key health messages to farmers through health promotion campaigns.

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Food for 9 billion: a perspective on global agriculture in 2050



Dr Dominique van der Mensbrugge, FAO, gave the second lecture in the Teagasc/RDS lecture series. Here he summarises the main points of his lecture: ‘Will we run out of natural resources needed for food production?’.

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Concerns about the planet's ability to feed a growing population date back to at least the beginning of the 19th century with Reverend Malthus' dire warnings, and were echoed again in the 1960s and 1970s. Despite these warnings, global population increased by 3.5 billion between 1960 and 2005, and global output and agricultural production increased by factors of six and three respectively. Since 1970, average caloric intake in developing countries has jumped from just over 2,000 per person per day to over 2,600. Despite these achievements in meeting food needs, there remain nonetheless significant pockets of poverty and undernourishment, and the sustainability of agricultural practices is a major concern.

The more recent agricultural price spike has rekindled this age old debate of agricultural production and sustainability. A new report by the Food and Agriculture Organization of the United

Nations (FAO, 2012) argues that with decelerating population growth and saturation of diets in many parts of the world, agricultural production growth will increase by some 60 percent between 2005 and 2050 – a huge drop from the 170 percent increase observed between 1960 and 2005. The report highlights, nonetheless, that concerns about poverty and undernourishment and agricultural sustainability will persist in the future. Beyond these traditional concerns, the potential impacts of climate change and the emergence of bioenergy will undeniably shape the future – even if their impacts are still highly uncertain.

The main drivers: population and income

The slowing of world population growth over the next 40 years, an additional 2 billion people, means that agricultural production and consumption are also expected to grow less rapidly. The growth rate varies across countries, however, and those countries whose populations continue to increase rapidly are precisely those that currently exhibit high levels of undernourishment. Nearly two-thirds of the expected population increase will occur in South Asia and sub-Saharan Africa. Global GDP is projected to grow 2.5-fold by 2050, resulting in a world that is richer and with less-pronounced income gaps between developed and developing countries. But global income growth alone is not expected to eliminate poverty and undernourishment.



Pictured at the Teagasc/RDS lecture series are (from left): Dr Lance O'Brien, Teagasc; Colm Hayes, Department of Agriculture, Food and the Marine; speaker Dr Dominique van der Mensbrugge, FAO; Dr Mark Holderness, Executive Secretary, Global Forum on Agricultural Research; Dr Cathal O'Donoghue, Teagasc; and Professor Jim Phelan, UCD.

Structural change in demand

While population and income growth in developing countries will spur demand, significant parts of the world will approach saturation of per capita consumption levels. The result is a halving of annual demand growth to 1.1% per annum. Convergence towards developed countries' consumption patterns is not inevitable everywhere, however, if only for cultural reasons. Demand will increase at all income levels, even where current levels appear adequate and additional growth may cause health concerns. This may happen even in countries where undernourishment remains significant.

The 1996 World Food Summit adopted a target of halving the number of undernourished people in developing countries by 2015 – to a level of some 405 million. With rising populations and uneven income growth, this target remains elusive and the report indicates that it may not be achieved until after 2040 even if the proportion of people who are undernourished is expected to fall by about four percentage points by 2015.

How will production respond? Contributions to growth

Yield growth has been the mainstay of historic production increases and will continue to play this role into the future. Some regions, notably sub-Saharan Africa and Latin America, may see more rapid growth in yields, closing the substantial "gap" that exists between actual and potential yields, provided that economic and institutional conditions are conducive. Local constraints to increasing yields remain a significant concern in many countries, threatening improvements in local food supplies in countries where they are most needed.

Some estimates suggest that there exists some 1.4 billion hectares of prime land that could be brought into cultivation. Much would come at the expense of pastures, however, and would require considerable investment to make the land suitable for production and more accessible to markets. Globally, land under crops is projected to increase by some 70 million hectares by 2050. The spare land is concentrated in a small number of countries; constraints may be very pronounced in other regions. Where these constraints are coupled with fast population growth and inadequate income opportunities, land scarcity can lead to more poverty and migration, and will remain a significant constraint in the quest for achieving food security for all.

Water is another critical resource, and irrigation has played a strong role in contributing to past yield increases. World area equipped for irrigation has doubled since the 1960s, but the potential for further expansion is limited. While water resources are globally abundant, they are extremely scarce in the Near East and North Africa, South Asia and in northern China, where they are most needed. Most of the world's irrigated agriculture currently occurs in developing countries (almost half of this in China and India), where it accounts for some 60 percent of cereal production. A net increase of 20 million hectares is expected by 2050; nevertheless, investment needs in irrigation to 2050 will need to be much higher to account for depreciation of existing infrastructure.

Global resources are sufficient, but the outlook is uneven

Evidence cautiously suggests that, at the global level, agricultural production can be increased enough to satisfy the additional 60 percent growth in demand projected to 2050, considering both food and non-food uses. However, resource availability, income and population growth are unequally distributed. Food security will remain a challenge at local, household and individual levels, and some countries will need to increase food demand more quickly than in the past, and through a broader-based economic growth if they are to achieve it. Such countries are typically those characterised by persistent poverty and high population growth.

Risks and uncertainties remain

The scenario depicted in the report is certainly not inevitable, nor is it necessarily optimal from some perspectives. Healthier diets, reduction in waste and losses, the elimination of hunger, improved food security (at all levels of society), and sustainable farming practices should be primary objectives of agricultural and food policies looking forward. Even taking the "glass half-full" perspective, there remain many risks in the outlook. The scenario assumes sufficient investment and policy support in the agriculture sector. The emerging linkages between agriculture and energy present both an opportunity and a risk in relation to food security. Significant changes in energy prices would potentially divert commodities and land to renewable energy production, increasing the demands on the agriculture sector. Moreover, the projections are set in a future where the impact of climate change is not yet fully understood. Each of these assumptions is a source of uncertainty that could alter the ability of the agriculture and food sectors to meet demand and reduce undernourishment.

Lecture 3 in the Teagasc/RDS lectures series 'Europe's Role in Food and Nutrition Security' will take place in the RDS on Thursday April 11 at 6.30pm and will be delivered by Dr Shenggen Fan, Director General of the International Food Policy Research Institute (IFPRI).

Reference

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Speakers who took part at WDS 2012 IDF 'SWIFT' conference (from left): Dr David Everett (New Zealand), Active Member of the IDF Standing Committee on Dairy Science and Technology; Dr Nico van Belzen (IDF Director General); Anne-Karin Edman (Sweden), Vice-Chair of the Standing Committee on Environment; Dr Kieran Jordan (Teagasc Food Research Centre Moorepark), Chair of the Standing Committee on Microbiological Hygiene; Michael Hickey (Ireland), Chair of IDF Science and Programme Coordination Committee; Richard Doyle (Canada), President of International Dairy Federation.

World Dairy Summit

Dr Phil Kelly reports on the International Dairy Federation's World Dairy Summit 2012, which took place in Cape Town, South Africa.



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Volatility, uncertainty, complexity and environmental sustainability were a few of the expressions highlighted by some of the world's top executives as major challenges facing the dairy industry at the World Dairy Leaders' Forum during the International Dairy Federation World Dairy Summit 2012 which took place in Cape Town, South Africa, October 31 to November 8, 2012. The mega trends currently dominating the global dairy industry include the rise of emerging markets, social demographics, urbanisation and the rising demand for dairy's nutritional benefits.

Dairy leaders appeared to be in agreement about the need to produce more on a worldwide scale, but with a localised approach in a global world. This stems from the imbalance of supply, emanating mainly from the developed world, and demand, estimated at 95% of future growth, to be found mostly in the developing countries. The 2012 Summit's location in Cape Town noted the mismatch in Africa between countries on the supply side and demand by those with higher GDP. Developments in the USA now sees 50% of the

country's milk produced on farms with herds >1,000 cows, while dairy farmer numbers have reduced from 130,000 to 50,000 over a 10-year period.

Major IDF Dairy Science & Technology Conferences 2016

The successful, long-running series of internationally run conferences under the auspices of IDF were secured at the Cape Town business meetings to take place in Ireland in 2016. Teagasc is to co-host with INRA (France).

For the first time both the Cheese Ripening and Technology, and the Spray Dried Dairy Products (SDDP) Symposia will be run in parallel with the potential to attract up to 1,000 participants. This is a major scoop for the Irish dairy industry and recognises the standing of Teagasc researchers as keynote speakers at previous IDF conferences and as active delegates in IDF's Standing Committee on Dairy Science & Technology (SCDST), including this writer as former Chair of the Standing Committee (2009-2011). The joint conference event is very timely as it coincides with the anticipated relaxation of EU milk quotas in 2015 and the projected expansion in manufactured dairy products such as cheese, milk powders, ingredients, infant milk formula and nutritional products.



Food

AT - Life Cycle Assessment (LCA) Development Monitoring Group	The 2010 IDF LCA guide is currently being updated by five working groups. Revisions will be presented at IDF WDS 2013 in Japan.
AT - Water Footprint of Dairy Products	Six working groups are contributing to the development of an LCA-based assessment methodology consistent with the future ISO water footprint norm (ISO CD 14046), as well as updating the 2010 IDF carbon footprint guide.
AT - Biodiversity and the Dairy Sector	Development of literature review and mapping of current global initiatives to measure biodiversity. A draft document will be presented at WDS 2013.

SWIFT development

The “SWIFT” initiative (Speedy, Worldwide Visible, Impactful, Focused and Transparent) is a new driver for the further development of IDF.

SWIFT, an initiative of outgoing President of IDF, Mr Richard Doyle, reported on its implementation. Teagasc food safety researcher and Chair of IDF’s Standing Committee (SC) on Microbiological Hygiene, Dr Kieran Jordan, was applauded for the speed with which he steered his expert group to examine the ‘Significance of Shiga-toxigenic *E. coli* (STEC) in dairy production for food safety’ and publish its findings in the *International Journal of Food Microbiology*. This microorganism is of primary importance to public health, though not all forms are pathogenic. The expert group highlighted multi-level complexity, e.g., the genetic make-up of STEC, definition of the pathogenicity of its strains and detectability in food. Control of STEC requires attention to good hygienic practices during milk production and adoption of appropriate measures along the entire food chain. The development of the first PCR-based ISO method was recognised as a major scientific advance and step forward in the harmonisation of different approaches. The review article is available for free download on the IDF website (Farrokh, C. et al., 2012).

New method of protein quality

A new method of protein quality assessment was announced at WDS 2012 called Digestible Indispensable Amino Acids Score (DIAAS). The method was developed by New Zealand researchers and measures the digestibility of individual essential amino acids (EAA) in the small intestine. Protein digestibility measurement over the total digestive tract (PDCAAS) is now proven to be less accurate. Professor Paul Maughan (Riddet Institute, NZ) announced that DIAAS boosts the quality performance of dairy proteins by as much as 10-30%. High levels of EAA, amino acid digestibility and lysine bioavailability in dairy proteins makes them a vital food ingredient for managing protein energy malnutrition and supporting growth in young children. DIAAS is expected to be published shortly by FAO and will herald a sweeping change in how dietary protein quality is determined and described.

Results will impact the dairy industry, food assistance programs and current standards in therapeutic nutrition practice. Higher quality proteins mean that lower dosages meet dietary amino acid requirements and ensure better use of scarce food resources.

IDF dairy sustainability

Meetings of IDF’s Standing Committee on Environment and its constituent Action Teams (AT) updated its current work (see text box) and was accompanied by a one-day conference on dairy sustainability that highlighted policy adoption among its member countries (www.dairy-sustainability-initiative.org).

Dutch Sustainable Dairy Chain: targets 2020

Mr Jan Maarten Vrij, Dutch Dairy Organisation (NZO) gave an overview of sustainability initiatives in the Netherlands:

Climate and energy

- 30% reduction of greenhouse gases in 2020 as compared to 1990, including climate-neutral growth
- 20% sustainable energy in 2020 and an energy-neutral dairy chain
- 2% energy efficiency per year (1.5% factories and 0.5% chain), and a total of 30% energy efficiency in the 2005-2020 period, 2% energy conservation for cattle farmers each year

Animal health and animal welfare

- Reduction of antibiotic resistance. By 2013, antibiotic use should be back to 1999 levels.
- Increasing average life expectancy of cows, particularly by the strong reduction of mastitis and lameness
- 5% sustainable housing in 2011. By 2015, all new cowsheds will be fully sustainable.

Grazing

- Maintain current level of outdoor grazing

Biodiversity and the environment

- 100% use of RTRS (Round Table on Responsible Soy) certified sustainable soya and sustainable palm kernel expeller by 2015
- Actions and measures that directly and indirectly influence phosphate release and ammonia emissions
- Improving biodiversity

Reference

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Horse meat traceability and identification in Ireland

Kevin Brennan, Teagasc Food Safety and Quality Specialist, explains the regulations governing the horsemeat processing chain.



Kevin Brennan

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The number of horses slaughtered in Ireland in recent years has increased dramatically and meat from those animals that qualify for human consumption are exported to many European countries where horsemeat is widely eaten (Dáil Éireann, 13/2/2013). In general, horses are not bred specifically in Ireland for the horse meat trade but a well documented boom in the horse population due to economic upturn and poor breeding practice by some owners has resulted in a surplus of animals of which some inevitably end up in horse abattoirs.

Article 2 of regulation EC No 178/2002 provides for far reaching responsibilities of food business operators (FBO) throughout all stages of the food production chain laying down procedures in matters of food safety and also traceability of food producing animals. Traceability has been the focus of attention for many years in the beef, poultry, pig and sheep processing industries and, as a result, these industries are now operating to extremely high standards. However, lesser focus has been placed on traceability for horse

meat production. There is little or no tradition of horse meat consumption in Ireland or the UK but nonetheless movement of horsemeat throughout and into the EU from other markets requires traceability standards at least equivalent to those for other more conventional meat products. For example, in the beef industry the capability exists to trace beef products back to farms of origin where a full history of the animal's welfare and medicinal records can be verified. The same standard must exist for horse meat to enable compliance with the basic legal regulations and also possible food safety implications.

Ante-mortem and post-mortem traceability

Regulation EC 504/2008 requires that equines must be identified and any medication administered to that animal checked to see if it conforms to maximum residue limits (MRLs) for veterinary medicinal products. Some of these residues for which no MRL has been fixed, e.g., phenylbutazone 'bute' must be declared in the animals identification document, from which point the animal is declared as not intended for human consumption. The identification document or animals 'passport' is an extremely important component of the traceability process for equines destined for human consumption. The passport should legally contain the following key data:

- Individual markings for that particular animal: The markings inspection, which is completed by an authorised veterinarian, includes all unique distinguishing markings, e.g., specific colourings on head and legs, whorls from the left, right and posterior orientations of the animal. Current regulations require that the foal is issued with a passport by the time it is six months of age.
- A Unique Equine Life Number (UELN). This number is documented in the passport. Use of the UELN system is a worldwide method of identification agreed between the major horsebreeding and competition organisations.
- The unique transponder 'microchip' number. The microchip incorporates a read only passive radio frequency identification device and when scanned by a microchip scanner should read the same number as that given in the passport.

The passport and the microchip, therefore, form a dual system of equine identification. The microchip is typically implanted between the poll and the withers in the middle of the neck in an area known as the nuchal ligament. One final aspect of the passport is that it contains the address and name of the animal's present owner so that traceability back to the farm/stable can be achieved. Passports, once issued, remain with the animal throughout its lifetime and must be returned to the issuing body when the animal dies.

Once the animal's identification has been checked and deemed fit for human consumption by the official veterinarian in charge in the abattoir, accepted by the FBO and passed all the appropriate animal welfare checks and controls, then the formal slaughtering of the animal proceeds. Traceability from this point onwards is akin to conventional beef slaughter where carcass numbers are allocated to each animal and key identifying numbers retained. The animal is then health mark stamped by the designated Department of Agriculture, Fisheries and Food (DAFM) official in the plant. Further processing requires the allocation of batch identification numbers to carcass consignments that meet a customer's own particular specification.

DNA identification

The use of DNA technology in the food industry is widely publicised and is a very useful technique when used and interpreted in the correct context. The use of DNA identification in equines is well established in Ireland particularly in the verification of the parentage of native breeds, e.g., Irish draughts and pedigree sport horses. Hair samples are removed from the foal at the marking stage and cross checked against the DNA database profiles of the specified dam and sire. In theory, this technology could be used to verify the origin of individual whole meat cuts assuming the animal DNA profile exists on a database. Its use for more processed comminuted meat products could, however, be more challenging.

Responsibility of FBOs in traceability verification

It is the responsibility of the abattoir management to ensure that all individuals presenting horses for slaughter have valid and fully completed passports as outlined above. An additional requirement from DAFM is that a food chain information record is completed for each animal presented. This document further reinforces the traceability of that particular animal where the passport number is recorded and the transport vehicle details are registered. The

document also references transport times and includes the name of the private veterinary practitioner who may have treated that animal. This may be particularly useful where independent verification of the medicinal record is sought.

The FBO should verify that the passport is authentic and unique with cross-referencing to the designated issuing bodies, for example Horse Sport Ireland amongst others. The microchip should be scanned and cross referenced with the chip number specified in the passport. Care should be taken to ensuring that only one microchip exists and that any evident clinical signs for example scarring indicating that a previously implanted microchip had been surgically removed are absent. The marking chart in the passport document should also be carefully crosschecked against the markings on the animal.

The medicinal record history, which if administered to the animal should be verified and, as a useful spot check, a designated random number of animals may be selected from which the private veterinarian specified is contacted and medicinal record cross checked. Animals can only be slaughtered for human consumption once the above traceability checks are satisfied and the animal has passed the antemortem inspection of the official veterinarian in charge. The FBO needs to ensure that all microchips are removed from carcasses and destroyed.

Conclusion

Traceability in the meat industry is a fundamental prerequisite requirement. FBOs not only have to demonstrate traceability from a legal context, but it also provides additional assurances to valuable customers and consumers alike. Likewise, in incidences of food safety concerns, the ability to quickly trace and identify product is vitally important both from a human health context but also an economic point of view. Latest provisional figures (Dáil Éireann, 13/2/2013) indicate twenty thousand plus horses slaughtered in local authority-approved abattoirs and thirty thousand plus from DAFM approved abattoirs demonstrate that horse meat processing is very much an increasing and established business in Ireland. Although it is not clear if all the above carcasses have qualified as fit for human consumption, it is assumed that a large proportion qualifies for the human food chain. The resulting multitude of horse meat products from whole cuts to comminuted products and further processed products magnifies the importance of traceability and quality assurance in this market. In Ireland this is particularly important where we rely massively on maintaining the excellent reputation of the integrity of our entire food chain.

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Cheese diversification and quality

Research to underpin cheese industry development in response to an increasing milk pool is underway at Teagasc Food Research Centre, Moorepark.

production from 80,000 tonnes in 1995 to 180,000 tonnes in 2011 (CSO) and is anticipated to reach about 215,000 tonnes by 2020. Crucially, it is an export-led industry with 92.8 % of production exported in 2011, equating to 167,000 tonnes (CSO).

Challenges/Opportunities: The importance of cheese research

Notwithstanding the significant opportunities available, considerable technical challenges are posed in processing of this increased milk pool and in producing diverse, market-led products of consistently high quality within the context of a seasonal milk production system. Some of the more important challenges may be considered as follows:

Seasonal milk production

The cheese industry already operates in an environment where seasonal milk production means redundant processing capacity for a portion of the year. In addition, as stage of lactation of milk advances the cheese making quality of milk diminishes with implications for cheese quality and consistency. Increased milk production will drive innovation needs for: (i) methods to increase cheese plant throughput capacity while minimising capital expenditure, and, (ii) technologies to minimise the impact of seasonal variations in milk compositional, physico-chemical and biochemical profiles on cheese quality and consistency. This drives the need for research and innovation in areas such as membrane concentration and milk protein fortification.

Cheese: An important and growing sector

Abolition of milk quotas in 2015 is projected to result in a 2.75 billion litre increase in milk production by 2020, equivalent to an increase of approximately 50%. This is expected to enhance the value of primary production by about €700 million along with further downstream benefits in the form of increased dairy products, export earnings and employment (Food Harvest 2020). However, it also poses significant challenges in processing of this milk pool and in leveraging greater share of existing dairy markets and, crucially, in the development of new products to avail of new market opportunities.

Cheese has been targeted as a vital end-product for this increased milk pool due to continued increases in global cheese consumption, high end-use versatility, potential for significant added value, and as a profitable outlet for surplus milk fat. Surprisingly, cheese has not historically been a major component of the Irish dairy product mix and its share in milk utilisation has always lagged well behind that of European competitors. However, this is fast changing as evidenced by the growth in natural cheese



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Reduction of fat and salt contents in cheese

Continued consumer interest in reduced and low-fat dairy products as well as growing consumer demands for reduced sodium contents poses particular challenges and opportunities for innovation in cheese. Fat reduction poses challenges in retaining desirable flavour and textural characteristics while reduced sodium contents may influence growth of both desirable and undesirable micro-organisms as well as impacting directly on cheese flavour profiles. Current research is focused on investigating optimal ways to achieve combined reductions in both fat and salt contents within cheese matrices while retaining consumer appeal.

Optimisation of cheese quality and consistency

Cheese is a highly complex and dynamic biological system produced from a raw material of changing composition; thus, internationally, there is a continuous challenge to maintain optimal product consistency and quality. While research has focused on the role of cheese starter microflora in cheese ripening, there still exists a considerable knowledge gap relating to the role of non starter microflora, including Non-Starter Lactic Acid Bacteria (NSLAB) in achieving cheese of consistent quality and in the occurrence of sporadic defects. Examples of defects include atypical or unbalanced flavour or ripening profiles, gas formation/secondary fermentations and cheese colour defects. As part of the Cheeseboard 2015 project, DNA-based approaches such as quantitative real time PCR (qRT-PCR) and next generation sequencing (NGS) technologies, including pyrosequencing, are currently being employed to profile both dominant and sub-dominant microbial species within Irish cheeses. These methods facilitate the detection of both specific microbial populations and of encoded metabolic pathways and are being utilised to enhance the quality and consistency of Irish commercial cheeses by identifying:

- microflora responsible for specific defects;
- the origin of problem microflora (e.g., milk sources, process environments, etc.); and,
- profiling the evolution of dominant and subdominant non starter bacteria species and strains within cheeses during the ripening processes.

Diversification of national cheese portfolio

Traditionally, the Irish cheese industry has been heavily focused on Cheddar production (accounting for about 80% of cheese production); however, such markets have been predicted to grow more slowly than other semi-soft and semi-hard cheese types. A cheese diversification research programme within Teagasc is currently working to diversify the national cheese portfolio through the following:

- A public-private partnership between Teagasc and the Irish Dairy Board focused on developing a pipeline of new and diverse cheese types with specific flavours and functionalities to target key export market opportunities. In addition, third party large scale commercial cheese producers have engaged within this initiative on a project-specific basis.
- A strong interactive industry programme which is currently engaged in supporting some of the previous successes in cheese diversification which encompass eye-type continental cheeses, hard Mediterranean-type cheeses and novel Cheddar variants.

- Research focused on: (i) manipulation of specific cheese physico-chemical, biochemical, and microbiological parameters under changing processing conditions to develop a range of cheeses with diverse characteristics, flavours and functionalities, but which are capable of being manufactured in existing commercial Cheddar production plants and (ii) investigation of the relationship between curd matrix physicochemical parameters and continental-type cheese quality produced from a seasonally-produced milk supply.
- Research investigating the influence of localised variations within the cheese matrix microstructure on the physiological state and metabolic activity of cheese bacterial microflora during ripening. This encompasses the development of new microscopic stain techniques to determine compositional and physicochemical variability and the application of Flow Cell Cytometry to determine bacterial physiological state/metabolic activity during cheese ripening. Such research will achieve a more optimised consistency in Irish export cheeses as well as facilitating greater diversification.

Benefits to industry

Increased cheese production provides very significant opportunities for utilisation of an expanding milk pool and for leveraging greater share of new and existing export markets. However, given the complexities of a highly complex and dynamic biological system that is cheese, new commercial opportunities will only be realised with an in-depth understanding of how to consistently manufacture and ripen diverse cheese-types using a seasonal milk supply.

The current cheese research programme encompassing key areas such as cheese diversification and quality in conjunction with a strong industry interactive programme is currently striving to deliver increased export opportunities in response to a considerable expansion in milk production post quota abolition in 2015.

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CheeseBoard 2015 is funded by the Department of Agriculture, Food and the Marine's Food Institutional Research Measure (FIRM) programme. Interactions between cheese matrix physico-chemistry, microstructure and microbial metabolic activity for cheese diversification and quality research is funded by The Dairy Levy Trust.

Figure 1. An anecic earthworm burrow present during the deconstruction of experimental mesocosms.



Promoting phosphorus in soils

Researchers are promoting phosphorus incorporation into soils using the soil biota.

Ensuring efficient nutrient cycling is a key component of sustainable intensification of Irish agriculture. Of the variety of soil-borne elements, phosphorus (P) is one of the key limiting nutrients to growth. The amount of P derived from fertilizer applications that is available to the plant is impeded by the complex interactions between P and the soil matrix. P is readily, and often strongly, adsorbed to both inorganic and organic soil components, based upon equilibrium between P concentrations in the soil solution and P that is already bound to such material. Therefore, the availability of water-soluble P following the application of fertilizer is quickly reduced and only a limited amount remains available to the plant at any one time.

This interaction also affects the vertical distribution of P in the soil profile. The application of inorganic fertilizer to grassland systems results in the rapid dissolution of the fertilizer applied, which produces a flush of water-soluble P at the soil surface. Such P is then readily adsorbed to the soil material, which results in the accumulation of P at the soil surface. This build-up of P at the surface can have a detrimental effect on the environment. In particular, P can be mobilised at the surface as heavy rainfall can erode top soil, transport it out of the field and deposit it into a water-body. The accumulation of P in a water-

body can stimulate eutrophication, which is a process that can pose risks to human health and aquatic ecosystems.

Recent research at Teagasc Crops, Environment and Land Use Research Centre at Johnstown Castle has investigated how biological processes can reduce such P accumulation in the top soil. The primary process investigated was the ability of earthworms to vertically transport material from the soil surface into the soil profile.

Earthworms and nutrient incorporation and cycling

Earthworm communities have substantial effects on the soil environment and can actively move and mix soil material within the soil profile. Based upon the zone in the soil profile which they typically inhabit and how they develop their burrows, earthworm species are classified into three ecological groups: epigeic, endogeic or anecic. Epigeic types are noted for living within the litter layer and in close proximity to the soil surface; endogeic types spend their entire life cycle belowground and feed on soil material as they burrow through the soil; anecic earthworms are also surface-feeders but produce semi-permanent vertical burrow networks (Figure 1). These burrow networks allow for direct access to organic material on the soil surface. When feeding on surface material, these earthworms pull such material belowground into their burrows, which can redistribute organic material in the soil profile. Through the incorporation of organic

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material, these earthworms also indirectly incorporate soil material and thus can promote a more even vertical distribution of nutrients.

Whilst earthworms can facilitate the incorporation of surface material into the soil, they can also stimulate nutrient cycling. Earthworm burrows provide a unique environment for other soil organisms, in that they are lined with mucilage that is exuded from the earthworm skin. This mucilage is produced to facilitate the worms' movement through the soil, but the accumulation of mucilage on the burrow wall provides a substrate to soil microorganisms. This stimulates the development of distinct microbial communities that can actively cycle nutrients essential to plant growth in the earthworm burrow network. Such is the distinction between the burrow environment and other soil zones that the term 'drilosphere' is used to define the soil environment produced by earthworms.

Experimental design

To investigate whether the presence of earthworms can facilitate the incorporation of P into the soil profile, a glass-house based mesocosm experiment was conducted (Figure 2). This experiment consisted of replicated soil mesocosms, which were constructed using two sandy loam soils of contrasting fertility. The soil derived from a low fertility site was used to construct the lower layer (30 cm) and soil from a high fertility site was used to construct the upper layer (1 cm). Initial testing of the soil revealed that the labile inorganic P concentration in the upper layer was approximately seven times greater than in the lower layer. Following mesocosm construction, two different plant treatments were applied. These treatments involved the establishment of two plant communities with different diversities, either a single grass species (monoculture) or a polyculture of a grass, two forbs and a legume. Thus, these plant communities were applied to investigate the effects of plant community structure on microbial assimilation of P and soil biological community structures.

The plant communities were allowed to establish and mature for six months before earthworms were applied. The earthworm treatment consisted of earthworms from two ecological groups. Three anecic earthworms (*Aporrectodea longa*) and six epigeic earthworms (*Allolobophora chlorotica*) were applied to each relevant mesocosm. Mesocosms were subsequently maintained for nine months before they were deconstructed into five depth ranges (0-1, 1-5, 5-10, 10-20 and 20-31 cm) for laboratory analysis. P concentrations at each depth range were determined to explore any differences in the vertical distributions of P between the earthworm applied and earthworm absent treatments.

Results and conclusion

The presence of mixed plant communities promoted a less even vertical distribution of P compared to the grass-only plant communities. This was attributed to greater P assimilation by the mixed community, which may be explained by the development of different rooting architectures by different plant species. By occupying different areas of the soil, these rooting systems would

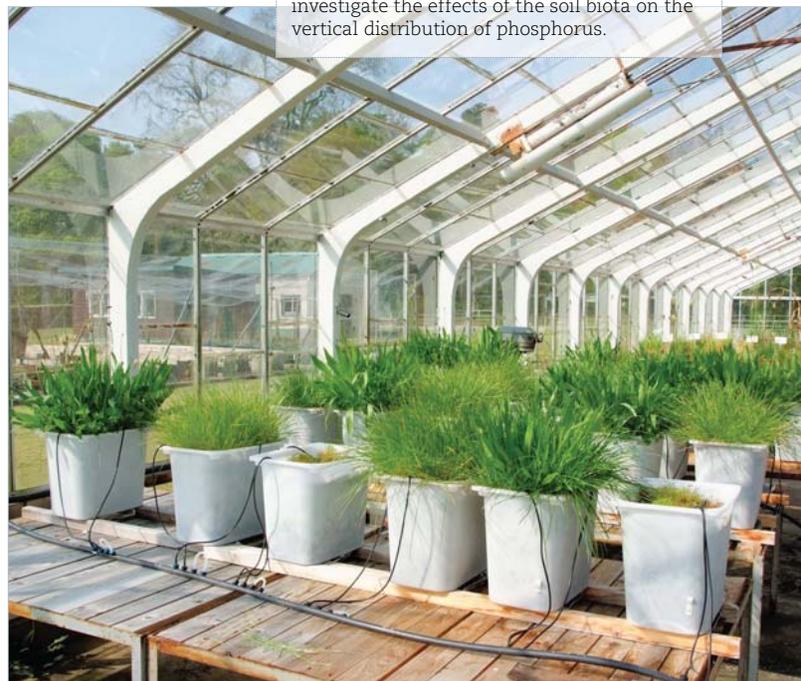
increase the total volume of root biomass present within the soil matrix and increase the exposure of P to the plant community.

Whilst a less even distribution of P was observed with increasing botanical diversity, the presence of earthworms promoted a more even P distribution. This was associated with decreasing P concentrations in the top layer of soil, which was likely realised by the burrowing behaviour of the worms. Therefore, this experiment provided supporting evidence for the ability of earthworms to promote a more even distribution of a highly immobile nutrient like P by reducing concentrations in the area of soil most at risk to erosion. Furthermore, P that is mixed into the soil through earthworm activity would still remain available to the plant community. This ability is not only linked to the ingestion of soil material by the earthworm, but also to the interactions that earthworms share with other soil organisms. We hypothesise that the incorporation of material into the drilosphere may stimulate the assimilation of P by the soil microbial community, which can promote greater P cycling in this specialised area of soil. Whilst the benefits of earthworms are evident, further research is required to explore the practical means by which farmers can utilise and stimulate such communities to facilitate the vertical incorporation of P in the soil.

Acknowledgements

This research was funded by the Teagasc Walsh Fellowship Scheme. The authors also wish to thank the technical staff at Johnstown Castle for their help and input throughout the study.

Figure 2. Experimental mesocosms designed to investigate the effects of the soil biota on the vertical distribution of phosphorus.





Halloysite formulation on the left, conventional treatments centre and right.

Novel plant protection products



Researchers in Teagasc’s Horticulture Development Department, UCD and TCD have developed a novel environmentally friendly encapsulated formulation for non persistent pesticides

Background

Currently, within the EU there are approximately 300 active ingredients permitted for use in plant protection. However, in order to achieve the aims of the Sustainable Use of Pesticides Directive, it is necessary to find safer and more acceptable ways of using these valuable plant protection tools. As a consequence of increasing environmental and human health concerns, whole groups of synthetic insecticides, for example, the organochlorines (including DDT), were removed from use because of their extreme persistence and bioaccumulation within the wider environment and human food chain.

The most widely used pesticide for the control of major soil borne pests in horticulture today, such as Vine Weevil and Cabbage Root Fly is the organophosphate (OP) insecticide, chlorpyrifos. However, the (anticholinesterase) organophosphate and carbamate compounds - that largely replaced the organochlorines - are not sufficiently persistent for effective soil pest control when used as conventional spray formulations. Such pesticides had to be formulated as granular products (for example, phorate and carbofuran) for within drill application to field crops, and by encapsulation of the active ingredient within a plastic resin matrix to create a controlled release technology for use in the peat-based media

used in protected horticultural crops.

Increasingly, however, the anticholinesterase insecticides are in turn being withdrawn from use, particularly on food crops, because of medical concerns regarding the potential long-term effects of chronic exposure on human health. The widespread use of controlled-release formulations of chlorpyrifos for the control of soil pests will therefore most likely end in the near future. The control of major soil pest problems will then become a serious challenge for producers. While biological control of insect pests is becoming increasingly effective in protected cropping, it remains relatively ineffective in outdoor field production.

Given the current process of gradual withdrawal of older (OP and Carbamate) products and the marked scarcity of new active ingredients being commercialised, it is timely to address the potential of innovative new applications for existing active ingredients that are not currently under the threat of withdrawal from use. The synthetic pyrethroids are the most widely used of the recently-developed insecticide groups. However, few if any pyrethroid formulations are considered suitable for application to soil or plant growing media, because on soil contact they rapidly degrade. Despite this, the synthetic pyrethroids represent one of the most potent insecticide groups known. The development of a successful, controlled release formulation technology to facilitate their use against soil pests would represent a considerable advance in pest control technology, and since they would be rapidly degraded following release at the site of action, such a development would provide considerable environmental benefit.

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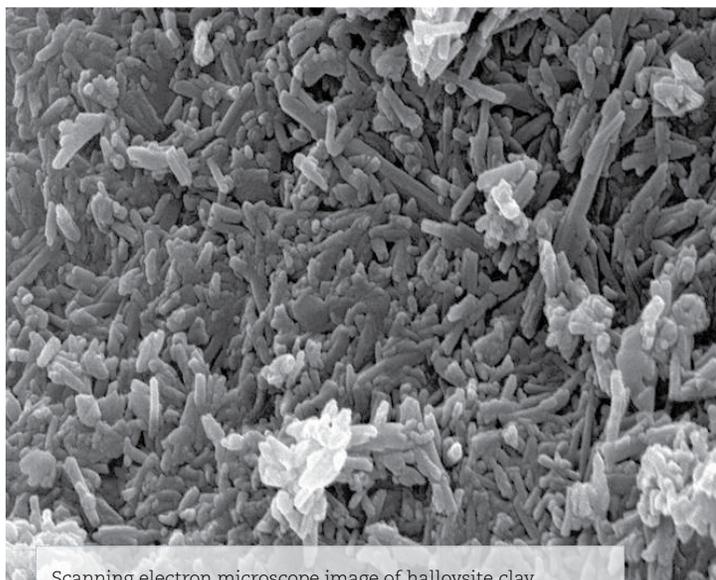
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Encapsulation using a natural mineral carrier

Halloysite is an inexpensive naturally-occurring clay aluminosilicate mineral, mined in several regions around the world. It is chemically similar to kaolin, but differs morphologically in that it assumes a tubular rather than a plate-like structure. This tube-like morphology gives halloysite the unique ability to entrap active ingredients within its interior, in addition to less extensive chemisorption onto the external tubule surface. The clay surface normally carries a net negative electrical charge. This facilitates gradual release of adsorbed chemicals from the internal structure at a relatively slow and controlled rate. As a naturally-occurring clay material, halloysite is fully bioerodible and environmentally friendly, in contrast to the synthetic plastic resins used in conventional controlled release technology, which can create problems for the disposal of spent growing media.

Effectiveness in comparison with current technologies

Both chlorpyrifos (a conventional OP insecticide) and cypermethrin (a candidate synthetic pyrethroid generally considered too unstable for soil application) were incorporated into halloysite clay at rates equivalent to a commercial chlorpyrifos formulation in a slow release plastic resin product (750g a.i./m³). Halloysite clay was initially mixed with the active ingredient of choice, and then liquid paraffin and a dye added. This mixture was then processed into pellet form and incorporated into a peat-based growing medium used to pot up begonia plants. Pots were artificially inoculated with vine weevil eggs either 4, 12 or 20 weeks after planting. Over a subsequent 20-week period, there was no statistical difference in the level of weevil larval population control achieved by each formulation, which exceeded 85% in all cases and would be deemed acceptable in commercial practice. Similarly, there was no difference in plant root development or plant vigour. This is important as chlorpyrifos, in particular, is known to cause phytotoxicity if used at higher than optimum application rates. Our results therefore clearly demonstrate a sufficiently controlled release of chlorpyrifos from the halloysite carrier into the growing medium.



Scanning electron microscope image of halloysite clay (magnification x25,000)

The relative performance of halloysite formulated cypermethrin, in comparison with an industry standard chlorpyrifos formulation, was particularly encouraging. To further test its effectiveness, new formulations of cypermethrin-loaded halloysite were made using the original rate, and a reduced rate of only 10% of this original rate. Given the propensity of cypermethrin to degrade very rapidly in mineral soils (half life normally between 0.6 -1.9 days) these new formulations were tested in a further pot experiment using both a natural field soil (grey podzol with 4% organic matter) and a peat-based growing medium. Again, a commercial plastic resin-based chlorpyrifos formulation was included for comparison. After 40 weeks, pots were inoculated with vine weevil eggs. The subsequent level of weevil larval control using both the original and reduced rate of cypermethrin exceeded 85% in the peat-based medium, and was greater than that achieved by the conventional chlorpyrifos formulation. This finding has been replicated in further studies, indicating that the novel formulation of a synthetic pyrethroid has very considerable potential for pest control in peat-based media. In the natural mineral soil, the standard chlorpyrifos formulation performed better than either halloysite formulation. However, the higher rate cypermethrin still gave an encouragingly large (>70%) reduction in larval numbers, which compared favorably with the level of weevil control achieved by the resin-based chlorpyrifos formulation when used in the peat-based growing medium.

Benefits to Horticulture and Agriculture

This development may allow the use of active ingredients that would not normally be considered suitable for use against soil insect pests. Our findings will likely increase in relevance to the management of soil pest problems in protected cropping when existing and widely used insecticide formulations are withdrawn from use. Halloysite products could also play a significant role in protecting outdoor field crops, as they are fully bioerodible and would not present the same environmental issues as synthetic resin-based products, hence leading to significant environmental and cost benefits for field based agriculture. For this reason, further refinement of the halloysite delivery system for use in natural mineral soils warrants serious attention. In practical use, this technology has significant potential benefit to growers and farm workers in reducing operator hazards; for example, in comparison to the use of plant module drenches for the control of cabbage root fly. The duration of effectiveness displayed by halloysite incorporation (up to 40 weeks) suggests that the precision placement of pesticide-loaded halloysite pellets when sowing field crops could also reduce the need for repeated spray applications against pests such as carrot fly.

While our studies have focused on the control of soil insect pests, there is also an opportunity to apply the use of halloysite formulation in the development of controlled-release foliar sprays that could extend the effectiveness of a wide range of plant protection products, including fungicides. As legislation governing pesticide application increases, there will be a definite advantage in using a natural carrier material for extended and more effective pesticide delivery.

Acknowledgements

This work was supported through the Teagasc Walsh Fellowship Scheme.

Cereal yields in 2012 what went wrong?

Teagasc researchers explain what caused poor cereal yields in 2012.

The 2012 cropping season was characterised by a warm winter and spring followed by a very wet and dull summer. Teagasc harvest report data showed cereal yields were significantly reduced compared to the 2011 season; winter wheat yield was 29% down, spring wheat 28% down, winter barley 15% down and spring barley 19% down. But what was it about the season that actually caused the low yields?

There are a wide range of factors that have been suggested anecdotally as being the cause: high levels of barley yellow dwarf virus (BYDV), Take-all, foliar disease and ear blight, water logging effects and poor grain-filling conditions. Without detailed monitoring, it is difficult to identify which of these were most important, and if growers could have altered crop management to minimise the losses.

Barley yellow dwarf virus

BYDV is an aphid transmitted virus, introduced when aphids carrying the infection from last year's crop migrate into the crop soon after emergence. The warm overwinter conditions meant that there was a much longer period of activity for aphids in the autumn and winter increasing the risk of high levels of BYDV infection. There were some instances

of high levels of BYDV infection and reports of poor insecticidal control of aphids, possibly caused by insecticide (pyrethroid) resistance, which has been reported elsewhere in Europe. Generally, the characteristic yellowing and stunting of plants which would be seen in the spring and summer were not common, and it seems unlikely that widespread BYDV is the cause of the national yield reduction.

Take-all

Take-all (*Gaeumannomyces graminis* var. *tritici*) is a soil-borne fungus that spreads from the roots of a previously infected crop to the roots of the current season's crop in the autumn. It is, therefore, usually worst on second or subsequent cereals in a sequence. The autumn, or primary infection, usually stops when soil temperatures drop. In 2012, due to the warm autumn and winter, there was a very prolonged period of primary infection and high levels of infection could be found in 'at risk' crops in January and February of 2012. The disease causes yield loss by destroying the vascular system of the roots and stem bases of the plant, and its effects are usually most severe when high levels of infection are followed by a dry summer, which exacerbates the 'droughting' effect of the disease. Whilst there were high levels of infection, the wet summer conditions will have reduced the impact on yield and commercially many second or subsequent cereal crops were reported to have yielded well.



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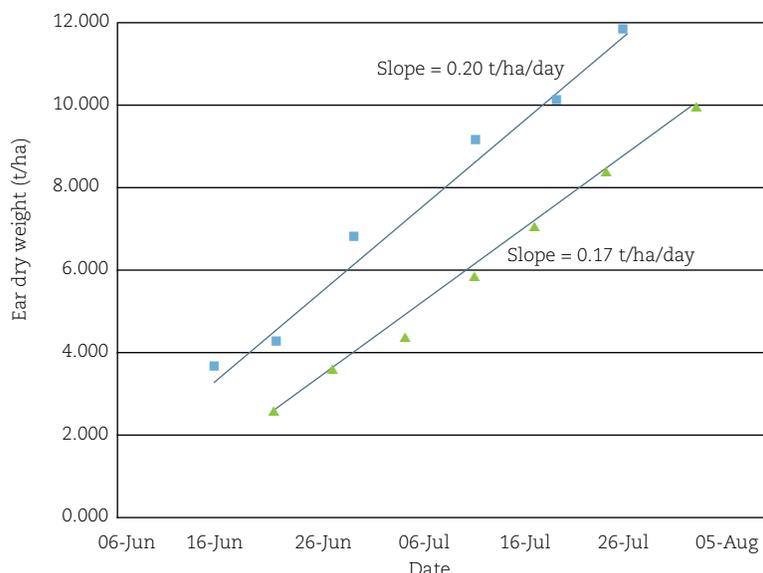
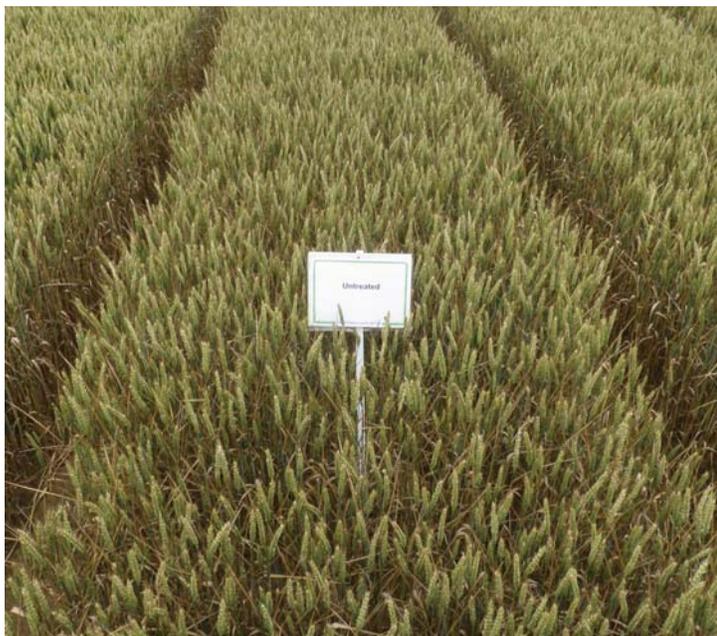


Figure 1. Ear growth rates from spring barley crops in Cork in 2011 (blue squares) and 2012 (green triangles).



Well-timed applications of fungicides provided good disease control of septoria leaf blotch even under the extreme disease conditions of 2012; untreated plots (left) vs. treated plots (right).

Septoria

The most damaging foliar disease in wheat in Ireland is Septoria Leaf Blotch (STB) (*Mycosphaerella graminicola*), which thrives during wet weather. The 2012 season, therefore, provided ideal conditions for high levels of STB. In 2008/2009 Teagasc monitoring of the Septoria population identified isolates that were less sensitive to the main triazoles fungicide used for its control at the time. Since then, monitoring and testing of the population has shown that the frequency of these insensitive isolates has increased, but there was no significant increase between the 2011 and 2012 seasons.

Additionally, a number of new fungicides with improved activity against Septoria from the Succinate Dehydrogenase Inhibitor group of fungicides (SDHIs) became widely used in 2012. Monitoring has found no insensitivity or resistance to this group. Teagasc field experiments carried out across the tillage area in 2012 showed that even with the very high disease pressure, sequences and mixtures of the different fungicide groups correctly timed to protect the top three yield forming leaves could provide very high levels of disease control. The level of disease and control that could be achieved even with a single application of an SDHI fungicide applied to the flag leaf can be seen in the photographs. Widespread yield loss due to Septoria should not have been an issue unless sprays were poorly timed or incorrect active ingredients or doses were selected.

Ear blight

Ear blight is caused by a range of *Fusarium* and *Microdochium* species which can infect cereal ears if flowering occurs during wet conditions. There were very high levels of ear blight infection in 2012. Given the range of flowering dates between tillers on a plant and florets in an ear it is impossible to time a single spray to cover all of the grain sites. In addition, even the best fungicides will only give a moderate amount of control and usually a 50% reduction in infection is about the best that can be achieved. In Teagasc field experiments in 2012, the best ear fungicides resulted in a 0.75 t/ha yield improvement over those not expected to give much control of ear blight. It seems likely, therefore, that yield loss due to ear blight could have been in the order of 1.5 t/ha where ear sprays were not correctly timed, which was very difficult to achieve in the 2012.

Wet weather conditions

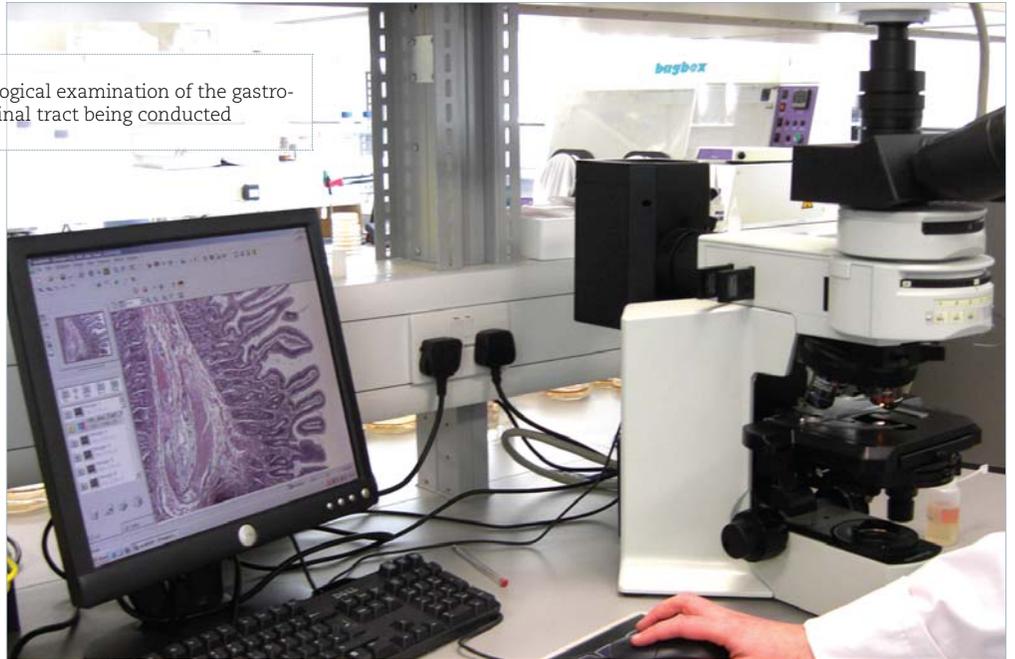
Very wet soil conditions and frequently water logging were a common feature in most areas during the summer of 2012, but particularly in the south with Moorepark recording 215mm and 88mm of rainfall for June and July respectively and Wexford recording 196mm and 108mm for the same months. In some crops there were obvious losses due to water logging, particularly in spring barley with areas of crop lost completely in wetter areas of fields. The scientific literature shows that even relatively short periods of water logging (three days) can have considerable long-term effects on crop growth and with reductions in photosynthesis of up to 80%. It is likely, therefore, that water logging was responsible for a significant proportion of the national yield loss.

Grain filling

Monitoring of crop growth and development in 2012 showed that grain filling started on average 10 days later than in 2011, and was two to six days shorter with incident radiation during the grain filling period 13-22% lower than in 2011. This reduction in the rate of grain filling is shown in Figure 1 and shows a 15% reduction in the rate of grain filling in spring barley reference crops grown in Cork in 2012 compared to 2011. This represents a significant reduction in source availability for grain filling, and its significance in terms of the reduction in national yields is supported to some extent in that wheat, which is a source-limited crop (i.e., it has the ability to store more carbohydrate than is available during grain filling), suffered greater yield reductions than barley, which in Irish conditions is usually a sink-limited crop (i.e., it can produce more carbohydrate during grain filling than it has grain capacity to store).

Whilst the 2012 season shows that crop production will always be at the mercy of the weather, the Irish weather is less variable than in some grain-producing regions of the world where in bad seasons almost complete crop loss can occur. Whilst the poor weather of 2012 has impacted severely on autumn plantings for 2013, the spring and summer weather will largely determine what the impact of this will be on productivity.

Histological examination of the gastrointestinal tract being conducted



Testing the safety of genetically modified (GM) feed ingredients in pigs

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A three-and-a-half year research project was conducted by staff of Teagasc's Pig Development Department to determine health effects in pigs fed genetically modified (GM) maize and peas. The results of this project are important, as EU consumer confidence in GM technology is low, largely due to perceived health risks associated with the consumption of GM food.

The GMSAFOOD project

Teagasc was a partner in the EU GMSAFOOD project whose principle objective was to determine the safety of GM food/feed ingredients. The consortium focused its work on Bt maize (MON810) and α -amylase inhibitor (α AI) peas, both of which were bred for their insect-resistant properties and grown in Spain. The work conducted by the consortium included:

- The production of α AI peas (CSIRO, Australia)
- Long-, medium- and short-term pig feeding studies (Teagasc, Ireland)
- Salmon feeding studies (NVH, Norway)
- Human immune response to potential allergens in GM peas using human-SCID mice (MUW, Austria)
- Food chain studies in which rats were fed pork and fish that had been raised on Bt maize (NVH, Norway)
- Epitope mapping and antibody determinations (CFRI, Hungary)

Pig feeding studies Bt (MON810) maize

Weaned pigs were fed diets containing non-GM or GM (Bt MON810) maize for 31 or 110 days. A trans-generational experiment was also conducted, whereby pregnant sows were fed non-GM or GM maize diets with the progeny of both groups being fed non-GM or GM maize diets to commercial slaughter weight. These experiments investigated the effects of GM maize on growth performance, intestinal histology, immune response, intestinal microbiology and organ weight

Neither the *cry1Ab* gene nor the Cry1Ab protein were found in the blood, organs or muscle of pigs fed the GM maize



and function. Analysis was also performed to determine if the gene encoding the protein responsible for the genetic modification of the maize, or the protein itself, moved out of the animal's digestive tract. The main results from this work include:

- Feed intake, growth rate and feed conversion efficiency of pigs were not adversely affected when pigs were fed GM maize.
- As an indicator of toxicity, the effect of GM maize consumption on the structure and function of the liver, heart, kidneys and spleen of the pigs was determined. Organ pathology and organ function were similar for pigs fed GM or non-GM maize.
- There was no adverse effect of feeding GM maize on small intestinal morphology.
- Comparison of the immune response of pigs fed GM maize or non-GM maize failed to reveal differences of biological importance. Antibodies specific to the GM maize protein (Cry1Ab) were not detected in the pigs' blood, indicating the absence of an allergic-type immune response to the protein.
- In addition to conventional culturing techniques, gene sequencing was used to determine if feeding GM maize influenced the bacterial profile within the digestive tract. Counts of selected culturable bacteria were unaffected by feeding GM maize. High-throughput gene sequencing revealed that GM maize consumption had only minimal impact on microbial community structure in the caeca of pigs, resulting in statistically significant differences in abundance of only 2 of 39 bacterial families and 3 of 54 genera detected. Furthermore, the taxa affected were detected at low abundance and frequency and their role within the intestine is not fully understood. Therefore, the differences observed are not believed to be of major biological importance and in addition, were not associated with any adverse health effects.
- Neither the *cry1Ab* gene nor the Cry1Ab protein were found in the blood, organs or muscle of pigs fed the GM maize. These findings indicate that the gene or protein did not migrate from the digestive system of the animal into other body tissues. Our results also indicate that the *cry1Ab* gene was broken down as it moved through the digestive system, being found in the stomach contents but not in the colon. As anticipated, fragments of the Cry1Ab protein were found throughout the gastrointestinal tract.

***α*-amylase inhibitor peas**

In a 31-day experiment weaned pigs were fed diets containing:

- Non-GM commercial field peas (*Pisum sativum* L.)
- Non-GM parent line peas (*Pisum sativum* L.)
- GM peas (*Pisum sativum* L.) expressing α AI-1 from the common bean (*Phaseolus vulgaris*).

This experiment investigated the effects of the α AI peas on pig growth, blood haematology, organ weight and function.

Feed intake, growth rate and feed conversion efficiency of pigs were similar regardless of treatment. Likewise, there was no difference in the weight of the heart, kidneys, liver or spleen between treatments and evidence of pathology was absent from the organs of pigs fed all of the pea treatments. Differences were observed in haemoglobin concentration and hematocrit between treatments; however, the

differences were only found between pigs fed the non-GM parent pea diet and pigs fed the other two pea treatments with no difference between the non-GM commercial field pea and the GM pea being found. Differences in mean platelet volume were also found between treatments; however, the GM pea was not different to the non-GM parent counterpart but was different to the non-GM commercial field pea. These results highlight the importance of correctly interpreting data on GM ingredients. Even a comparison between two conventional varieties of any feed ingredient is likely to yield differences in some parameters of interest. Therefore, it is important that feeding trials investigating the safety of GM ingredients should also include a comparison to conventional varieties of the same feed ingredient.

Conclusions and implications

Based on our results the GM maize did not have harmful effects on growth, intestinal health or organ function of pigs. Bacteria within the digestive systems of pigs are tolerant of the GM maize. In addition, the *cry1Ab* gene as well as the protein itself have been shown not to migrate from the digestive tract and the gene was broken down as it progressed through the digestive tract. It was concluded that feeding GM maize to pigs of different ages and for extended periods of time is as safe as its conventional counterpart with respect to potential effects on animal health. Furthermore, our results did not reveal any reason for concern regarding the safety of the α AI peas tested. The latter experiment highlights the need to include multiple conventional comparators of the same feed ingredient during safety assessment.

Acknowledgements

The research leading to these results received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement number 211820 and Teagasc's Walsh Fellowship programme.

See also: <http://www.gmsafoodproject.eu/>

For a full listing of peer reviewed scientific papers relating to this research see: <http://www.teagasc.ie/pigs/other/>

Image courtesy of Bord Bia



Breeding for quality

A new multidisciplinary research project is looking at breeding for improved product quality in dairy, beef and sheep in Ireland.

The world's population currently consumes 37 million tonnes of dairy products, 65 million tonnes of beef, and 13 million tonnes of sheep meat annually. This is expected to grow in line with population expansion. Food safety and the human health effects of food are currently high priority for consumers.

Breeding for improved product quality, in combination with optimised production and processing regimes, is one approach that will help the Irish dairy and meat sectors ensure animal products of consistently high quality and nutritive value are available. A recently awarded project, BreedQuality, will use state-of-the-art tools to develop phenotypic, genetic and genomic approaches for a national strategy to improve the quality and consistency of milk and meat products from Irish cattle and sheep. To achieve consistency in quality, however, the

underlying meaning of quality to consumers must be described, understood and translated into technical specifications at each stage within the supply chain. In other words, the determinants of superior quality must first be identified from a marketplace perspective and then explored from a technical standpoint. The first task of the BreedQuality project will be to document the relative importance of quality attributes in delivering consumer and customer satisfaction and this will help guide the focus of the 'breeding for quality' research.

Current status of breeding for quality in Ireland

Product quality is traditionally laborious and costly to measure, hindering the routine capture of such information. Therefore, product quality is one of the suites of traits largely neglected from the national breeding strategies in dairy, beef and sheep in Ireland. The national dairy breeding objective, the Economic Breeding Index (EBI), currently includes measures for milk protein and fat yield but does not include more detailed measures of milk quality. Similarly, the national beef breeding objectives include measures for

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carcass conformation and subcutaneous fat level as well as quantity of primal cut yield but they do not include any direct measure of meat quality. The national sheep index, The Sheep Value Index, includes carcass characteristics traits but no direct measure of meat quality. This is not sustainable in an increasingly competitive global market place.

To breed for product quality one needs:

- routine access to large quantities of accurate measures of product quality;
- knowledge of the contribution of genetics to differences among animals;
- an understanding of the impact of altering product quality on product portfolio and processing management systems; and
- knowledge of the weighting to place on product quality in national breeding objectives relative to other performance traits.

The BreedQuality project addresses all of these elements.

Breeding for milk quality

The task on milk quality in the BreedQuality project builds on recently completed research by Teagasc in the EU-funded project, RobustMilk (<http://www.robustmilk.eu>). Several methods are currently being explored to develop rapid, low-cost, approaches to routinely assess milk quality. Milk mid-infrared spectroscopy (MIR) is the method of shining light through individual cow and bulk milk tank samples, measuring the absorbance pattern of the light in the mid-infrared region of the electromagnetic spectrum, and using the wavelength absorption patterns to predict different milk quality characteristics. All milk samples in Ireland, during routine milk testing, are subjected to MIR; this MIR is currently used to predict milk fat, protein and lactose concentration. Because MIR data are already generated in the milk testing protocols, the marginal operational cost of generating new MIR-derived measures is negligible. As part of the BreedQuality project, the ability of MIR to quantify the protein profile, micronutrient quantity, and functional properties of milk will be evaluated. If successful, the prediction equations will be immediately implemented to routinely predict milk quality attributes.

Clear genetic variation in many measures of product quality in dairy cattle has been established both nationally and internationally. For example, up to 43% of the field variation in milk saturated fat levels can be attributable to genetic differences among animals signifying that breeding for improved milk quality is indeed possible. The BreedQuality project will derive the necessary statistical models and parameters required to implement a national genetic evaluation for improved milk quality in Ireland.

Economic analyses will also be undertaken as part of BreedQuality to quantify what weighting, if any, should be placed on the different contributors to milk quality within the Irish national breeding objective, the EBI. We envisage that within three years Ireland will have implemented a world-class and potentially world-first national breeding strategy for milk quality parameters.

Breeding for meat quality

Like milk quality, breeding for improved meat quality is hampered primarily by the challenges of routine low-cost measurements of meat quality. However, unlike for milk, individual meat samples are not currently subjected to technologies that can be readily exploited to measure detailed meat quality components.

Research at Teagasc and elsewhere, nevertheless, suggests various secondary methods such as near infra-red (NIR) spectroscopy could potentially be useful to predict meat quality characteristics, particularly colour, drip loss, fat content and fatty acid composition. Near infra-red spectroscopy exploits information generated in this region of the electromagnetic spectrum and is amenable to online measurement. Recent Teagasc, UCD and international research has also shown that other tools, such as image analysis, including hyperspectral imaging, computed tomography and Raman spectroscopy are also capable of predicting important aspects of fresh meat quality.

International research clearly shows that although pre- and, in particular, peri- and post-slaughter management, play major roles in determining meat quality, animal breeding can still contribute substantially to improving meat quality. Approximately 20% of the variation in a range of meat quality traits in beef and sheep is due to differences in genetic merit. The BreedQuality project will also seek to identify genomic regions associated with important meat quality traits in beef and sheep meat using state-of-the-art technologies.

The BreedQuality project will also attempt to optimise post-slaughter management protocols, such as chilling regimes, on an individual carcass basis in accordance with meat quality predicted using the rapid measures, demonstrating the potential relevance of this technology to processors' meat management systems.

Economic analyses will also be undertaken in beef and sheep to evaluate what emphasis, if any, should be placed on meat quality within the Irish national beef and sheep breeding objectives. Unlike in dairying where the measurement equipment already exists, abattoirs will need to invest in the necessary equipment. This will only be considered if a favourable cost:benefit exists. Therefore, implementation of national phenotyping and breeding strategies for meat quality may be slower. Furthermore, fundamental issues in sheep like parentage assignment will hamper genetic gain (for all traits) in sheep but this is an area of active research.

Combining resources and knowledge

Routine access to large quantities of low-cost, accurate phenotypes, irrespective of the trait, will remain of fundamental importance in animal breeding (and management) for at least many decades. The BreedQuality project, involving animal scientists, milk and meat scientists, molecular and quantitative geneticists, market researchers and industry, will combine resources and knowledge to produce a set of close-to-implementation tools and algorithms that will result in the implementation of market-based national breeding strategies for improved milk and meat quality.

The BreedQuality project (11/SF/311) is funded by the Department of Agriculture, Food and the Marine's Research Stimulus Fund.



Ovulation synchronisation in lactating dairy cows

A compact calving period in the spring increases the profitability of pasture-based systems. Maximising submission rates is essential to achieve this. Can synchrony play a role?

In seasonal calving dairy herds, a concentrated calving pattern is achieved by maximising the proportion of the herd that successfully establish pregnancy in the first six weeks after mating start date (MSD) (target >75%). Submission for AI is frequently compromised due to anoestrous (i.e., cows yet to resume oestrous cyclicity post calving), in addition to both weak expression and poor detection of oestrus. In such circumstances, timed AI (TAI) programmes can be implemented. These TAI protocols tightly control the timing of ovulation, meaning that cows can be inseminated at a set time without requirement for detection of oestrus.

Controlling ovarian function

A follicle is a structure within the ovary that contains the oocyte (egg) before ovulation and is also responsible for producing the hormone oestradiol. High concentrations of oestradiol stimulate the hypothalamus (part of the brain) to release large amounts of gonadotrophin-releasing hormone (GnRH), which, in turn, stimulates the pituitary gland to release large amounts of luteinising hormone (LH). This is termed the LH surge, and ovulation occurs approximately 28 to 32 hours later. After ovulation, the cells within the follicle change to form a new structure called a corpus luteum (CL). The CL is responsible for producing progesterone (P4), an essential hormone for pregnancy establishment and maintenance. If a pregnancy is not established by 15 to 17 days after ovulation, the uterus releases a

hormone called prostaglandin $F_{2\alpha}$ (PGF). This causes the CL to regress and concentrations of P4 rapidly decline. This allows a large follicle to undergo final maturation and ultimately ovulation. The hormones GnRH, P4 and PGF, or their analogues, are approved for use as treatments in lactating dairy cows for oestrous synchronisation. We conducted two studies on lactating dairy cows using these three hormones. The first study involved detailed measurements of the ovarian responses to these hormones. The second study examined submission and conception rates and overall herd fertility performance.

Study 1: Ovarian effects

Lactating dairy cows (n = 57) were managed as a single herd at Moorepark and randomly assigned to one of the three synchronisation treatments (CIDR_OBS, CIDR_TAI or Ovsynch) illustrated in Figure 1. The CIDR_OBS treatment was an oestrous synchronisation protocol, whereas CIDR_TAI and Ovsynch were ovulation synchronisation protocols allowing TAI. The GnRH injection at the start of the protocol causes an LH surge, resulting in ovulation of any large follicle present on the ovary. This is necessary to start a new wave of follicle development (all protocols). A Controlled Internal Drug Release device (CIDR) is inserted into the vagina, and P4 is gradually released. Circulating concentrations of P4 are elevated for the period that the CIDR is inserted (CIDR_OBS and CIDR_TAI). For cows that have not yet resumed cyclicity, a CIDR can be used to supply P4, mimicking the role of the CL in cows that have already resumed oestrous cycles. The PGF injection on day 7 causes the regression of any CL on the ovary (all protocols). As a result of the CL regression and the removal of the CIDR device, circulating concentrations of P4 decline, allowing final maturation of the follicle. The GnRH injection at the end of the protocol (CIDR_TAI and Ovsynch) again causes an LH surge and induces ovulation of the dominant follicle.

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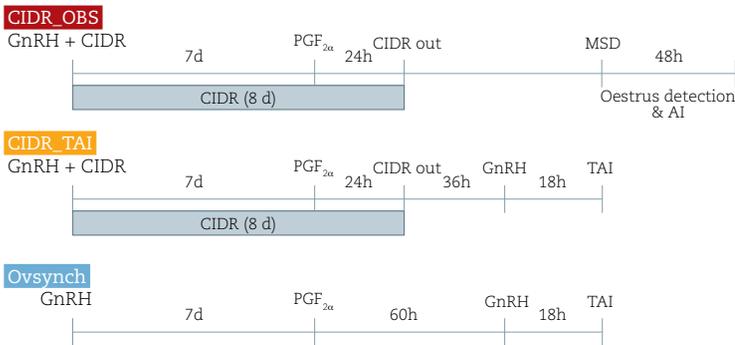


Figure 1. Treatment protocols to synchronise oestrus and ovulation, where CIDR_OBS = CIDR-based treatment requiring observation of oestrus; CIDR_TAI = CIDR-based ovulation synchronisation treatment allowing timed AI; and Ovsynch = ovulation synchronisation treatment allowing timed AI.

Circulating concentrations of P4 were greater for CIDR_OBS and CIDR_TAI compared with Ovsynch during the synchronisation treatment. All cows treated with CIDR_TAI and Ovsynch had ovulated by 92 hours after PGF (32 hours after GnRH), whereas only 53% of the cows treated with CIDR_OBS had ovulated at this time. Use of CIDR_OBS resulted in increased preovulatory follicle size and greater circulating concentrations of oestradiol due to a longer period of preovulatory follicle growth.

Study 2: Fertility performance

A study was conducted using 1,538 cows in eight Irish commercial spring-calving dairy herds. Within each herd, cows were divided into three groups: early, mid-, and late-calving based on days in milk (DIM) at the farm MSD. Early calving cows (n = 1,301) were ≥ 42 DIM at MSD, mid-calving cows (n = 212) were 21 to 41 DIM at MSD, and late-calving cows (n = 126) were 0 to 20 DIM at MSD. Synchronisation treatments commenced 10 days before MSD for the early calving cows, facilitating oestrus or TAI at MSD (planned breeding 1; PB1). Synchronisation treatments commenced on day 11 and 32 after MSD for the mid- and late-calving cows, respectively. The treatments facilitated oestrus or TAI 21 days after MSD (PB2) and 42 days after MSD (PB3) for the mid- and late-calving cows, respectively. All mid- and late-calving cows were between 42 and 62 DIM at AI. Within each calving group, cows were randomly assigned to one of three synchronisation treatments (Figure 1) or a fourth treatment that received no hormonal intervention (Control; CTRL).

The likelihood of successful conception per AI was greater for CIDR_OBS (59%), CIDR_TAI (54%) and CTRL (53%) compared with Ovsynch (45%). Both CIDR_TAI and Ovsynch had increased likelihood of earlier conception compared with CTRL (Figure 2). A greater proportion of cows on the CIDR_TAI treatment successfully established pregnancy in the first 42 days after MSD compared with the CTRL (75% vs. 67% 42-day pregnancy rate). In summary, protocols to synchronise oestrus and ovulation were effective at achieving earlier first service and conception in seasonal-calving dairy herds.

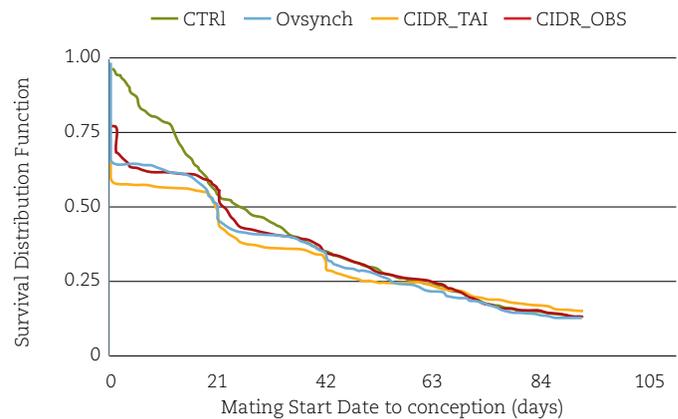


Figure 2. Interval in days from mating start date to conception.

Some general observations from the study were as follows:

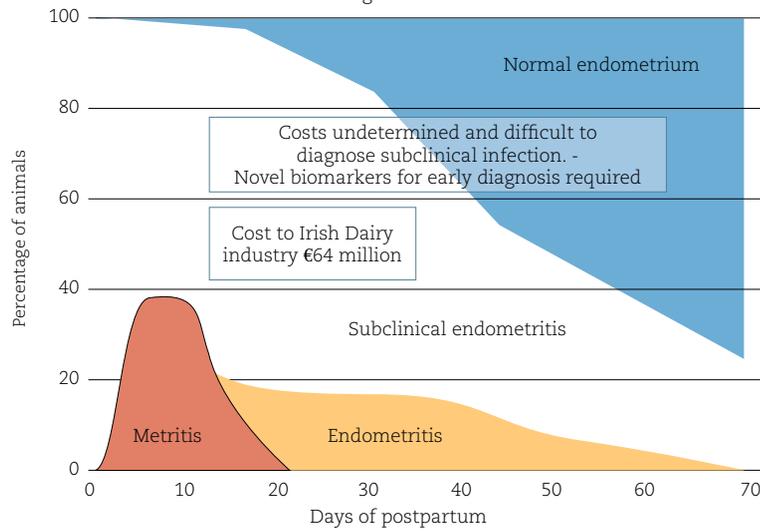
- Presence of a CL at protocol initiation, greater DIM at the onset of synchronisation, and greater body condition score (BCS) at the time of AI were all associated with increased likelihood of submission for AI and conception at first service.
- Both CIDR_OBS and CIDR_TAI animals without a CL (i.e., anoestrous) were more likely to establish pregnancy after first AI compared with Ovsynch animals without a CL (conception rates of 56, 52 and 34%, respectively).
- Animals with low BCS (≤ 2.50) treated with CIDR_OBS had increased likelihood of conceiving at first service compared with CIDR_TAI, Ovsynch, and CTRL (conception rates of 58, 44, 41 and 40%, respectively).
- Animals < 60 DIM treated with CIDR_OBS and CIDR_TAI had increased likelihood of conceiving at first service compared with Ovsynch (conception rates of 58, 50 and 32%, respectively).
- Treatment differences were minimal in cows categorised as medium or high BCS, ovulatory and > 60 DIM, indicating that CIDR-based protocols should be targeted at particular cows (thin, anoestrous or < 60 DIM), and all other cows should be synchronised using Ovsynch.

Benefits to industry

The findings clearly demonstrate that TAI protocols can be successfully used in seasonal calving Irish dairy herds as a tool to increase the proportion of cows becoming pregnant early after MSD. Though the impact on calving pattern will be greatest when used on a whole herd basis, targeted use of TAI for anoestrous and later calving cows may have the greatest application and cost benefit on most dairy farms.

This research was funded by the National Development Plan and the Dairy Levy Trust Fund and the Teagasc Walsh Fellowship Programme.

Figure 1



An integrated investigation of uterine disease



Teagasc researchers and University partners are developing biomarkers for the early detection of uterine disease.



Economic cost of uterine disease

All cows experience uterine bacterial contamination of the uterus after they give birth and approximately 40% of dairy cattle develop uterine disease such as metritis and/or endometritis. Unresolved bacterial infection of the uterine lining (known as the endometrium), induces chronic inflammation, reduces subsequent fertility and is associated with lower milk yields and increased veterinary intervention costs. Uterine disease costs the European Union €1.4 billion per annum. In Ireland, assuming a cost of €292 per cow and a conservative incidence rate of 20% in the dairy cow population, we estimate the economic impact of metritis alone to be in the region of €64 million per annum (Figure 1, adapted from Sheldon *et al.*, 2008).



Diagnosis and treatment of uterine disease

Regardless of the risks that predispose cows to uterine infection and different classifications of uterine disease, an inflamed endometrium and high uterine bacterial load is a typical phenotype of metritis. Twenty-one days postpartum (DPP), clinical endometritis is diagnosed by the presence of purulent material in the vagina and subclinical endometritis can be diagnosed by uterine cytology or histopathological analysis. However, the diagnosis of subclinically infected animals remains a challenge on farm and sub/infertile animals represent a major

problem for the industry.

Recent studies have found increasing incidence of multidrug resistance strains of *Arcanobacterium pyogenes* and *Escherichia coli* isolated from bovine uteri, which are two of the most common causes of endometritis in cattle. Therefore, the long term use of wide-spectrum antibiotics is not a sustainable therapeutic approach.

Uterine inflammation and immunity – joining the plots!

The current understanding of mechanisms linking bacterial infection, inflammation and subfertility involves the recognition of bacteria by pathogen receptors on uterine cells stimulating accumulation of prostaglandin E in the postpartum uterus resulting in a prolonged luteal phase, which is associated with postpartum uterine disease and subfertility. However, as all cows experience bacterial contamination of the postpartum uterus, why do some cows clear these pathogens effectively and others go on to develop uterine disease? Is the host-specific reaction to the same pathogens different between cows and, if so, is it either an over-reaction, resulting in too much inflammation and damage to host tissues; or a sub-optimal immune response allowing bacteria to survive and grow? For useful answers to these questions one has to perform integrated analyses at several levels, from uterine tissue to cells to molecules to genes with a particular focus on the interface between the uterine microbes and the endometrium lining the uterus.

Uterine biopsy and histological analysis

The uterus is a complex organ, composed of multiple layers of specialised cell types. In order to capture the

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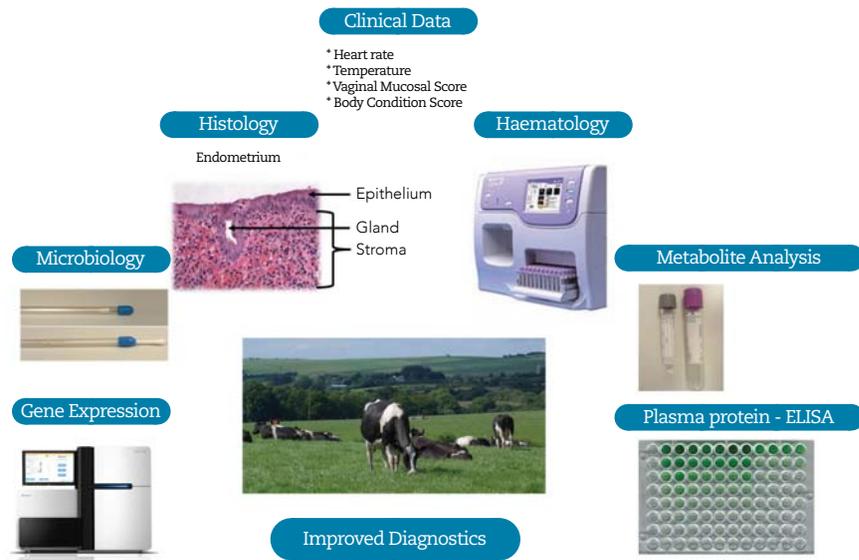


Figure 2

contribution from each of these layers, uterine biopsies are essential. Taken correctly and carefully, these valuable research tools do not have a detrimental impact on subsequent fertility. Histological analysis can assess the degree of inflammation in a uterine sample, classified based on numbers of polymorphonuclear cells, including neutrophils, under microscopic magnification. This technique allows the categorisation of uterine biopsies as either inflamed and endometritic, or non-inflamed and healthy.

Culture-independent identification of uterine bacteria

Although numerous studies have identified specific bacterial species associated with endometritic uterine environments, the majority have used culture-dependent techniques. More than 90% of microbial species have therefore been excluded using these analyses. This underestimation can be dramatically improved by using culture-independent techniques to characterise bacterial diversity of the uterus. Terminal Restriction Fragment Length Polymorphism (T-RFLP) is a culture independent technique that assesses the DNA sequence encoding the 16S rRNA gene to discriminate and identify the different populations of bacteria in a uterine swab. Our group are currently analysing uterine swabs taken at 7 and 21 DPP with T-RFLP in both endometritic and healthy cows to determine the bacteria present and to measure relative changes in these populations over time and in response to disease.

Advances in transcriptomic and related technologies

Transcriptomics is the study of the transcriptome, the entire complement of expressed genes in a cell or tissue, inclusive of mRNAs, non-coding RNAs and small RNAs at a given time point. Advances in technology now enable the identification of all genes present in the tissue of choice in an unbiased manner. A particular strength of RNA-Seq technology is that, unlike Real-Time RT-qPCR and microarrays, it does not rely upon existing knowledge of the genome sequence, and because it sequences what is present rather than what is captured, it can identify entirely new genes and expression products. Similar technological developments also facilitate the identification of other regulatory layers and molecules controlling gene expression including microRNAs and the chemical modification of DNA (epigenetics).

Recent studies of uterine immunology in Teagasc

Recent work performed in Teagasc, and in collaboration with University partners, has led to the concept that inflammatory responses that occur in the post-partum cow, are critical to the return of the uterus to a normal physiological state capable of supporting a subsequent pregnancy. Large numbers of genes have been shown to be differentially expressed in the post-partum uterus; and our work has shown a shift from the activation of immune pathways early post-partum to the upregulation of tissue repair and proliferation pathways in healthy cattle. Uterine inflammation is therefore part of the normal tissue remodelling process that occurs post-partum in healthy animals and is driven by bacterial colonisation. Dysregulation of this immune response may contribute to sustained inflammation and development of chronic infection. We propose that by using all the tools currently available in the Teagasc/Irish University research arsenal, that a comprehensive picture of the role of local immunity, as well as interactions between the immune and other systems in the post-partum bovine uterus, will identify potential targets for early therapeutic intervention and improving downstream fertility.

The future of diagnostics and therapeutics for uterine disease

At present, there are no reliable diagnostic techniques for subclinical uterine infection or disease in cows. What is emerging from our collaborative research is that the environment in the post-partum uterus is immensely complex, with contributions from the host, the pathogen(s) and the farm environment. We aim to integrate multiple layers of clinical, cellular, microbiological and molecular information (Figure 2) to define the mechanisms responsible for effective clearance of bacteria from the post-partum uterus. In particular, we aim to define the signature of response that predicts failure to clear bacteria, resulting in chronic infection, inflammation and subsequent infertility. No single system acts in isolation; integration of metabolic, endocrine and immune data will be critical to defining pathological and healthy signatures. It is clear that unresolved inflammation or failure of normal 'cleansing' of uterine bacteria post-partum can have knock-on downstream consequences for fertility. What is also clear is that the emergence of new reliable diagnostics will depend on a detailed understanding of the role the immune response plays in this process, and how dysregulation of the immune response contributes to the development of infection.

The ultimate goal of our research is to develop biomarkers of early detection of uterine disease in particular subclinical endometritis. Systemic detection of these biomarkers (e.g., in serum) would lead the way towards the development of diagnostics for uterine disease in cows. Identifying infection earlier prevents the reliance on the development of clinical symptoms, and is more likely to result in a favourable outcome in terms of fertility as well as cost.

Further reading

Sheldon I.M. *et al.* 'Uterine diseases in cattle after parturition'. *Veterinary Journal*. 176: 115-121.

Foley, C., *et al.*, 2012. 'Global endometrial transcriptomic profiling: transient immune activation precedes tissue proliferation and repair in healthy beef cows'. *BMC Genomics*, 13: 489.

Chapwanya, A. *et al.*, 2012. 'The postpartum endometrial inflammatory response: a normal physiological event with potential implications for bovine fertility'. *Reproduction Fertility and Development* 24: 1028-1039.

Events

March

7 March

Food Science and Technology Building, UCC

Biosensitives Advanced Stabilisation Formulation and Design for Food

Structure and Stability

The key area of the Workshop is food solids properties in spray drying and stability of sensitive components in dehydrated food structures. The Workshop will be of particular interest to those responsible for process and product development in the areas of food ingredients, dairy ingredients and infant formula manufacturing. On the day, Patrick Maher, Teagasc, Moorepark, will present on Spray Dried Nano-emulsions for Biosensitives Stabilization; Dr Song Miao, Teagasc, Moorepark, will present on Advances in Postdehydration Technologies; while Dr Mark Auty, Teagasc, Moorepark, will focus on Imaging of Micro- and Nanostructures in Food Materials. Other speakers include: Professor Yrjö H. Roos, and Yankun Zhou, UCC; and Professor Stephan Drusch, Technical University of Berlin. There will be a fee of €75 to cover local workshop organisation costs, including registration material, lunch and coffee. A few places will be made available to registering postgraduate students.

For queries and registration please contact Professor Yrjö H. Roos by email at yrjo.roos@ucc.ie

11- 12 March

Tullamore Court Hotel, Tullamore, Co. Offaly

Agricultural Research Forum

This annual two-day event will feature all the latest agricultural research from the major research institutes on the island of Ireland. The objective of the meeting is to provide an opportunity for the presentation and publication of new scientific information relating to the Sciences of Agriculture (including animal and crop science, molecular biology and biotechnology), Environment, Soil, Food, Agri-Economics and Forestry. The conference places an emphasis on novel, high quality research and on the professional presentation of results. The forum will provide an opportunity for scientists, specialists, advisors and others working in the above areas to interact and exchange views. Participation by industry personnel is particularly welcome.

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April

11 April

RDS, Dublin

Teagasc Lecture Series – Lecture 3: Europe's Role in Food and Nutrition Security

Agriculture, food security and nutrition are high on the EU's long-term development cooperation agenda and are an important aspect of the dialogue with partner governments. However, more efforts must be deployed to help vulnerable people respond to crises, and scale-up investments that improve food and nutrition security, especially in sub-Saharan Africa and South Asia. Innovations like biotechnology, nanotechnology, and biofortification that can raise productivity, build resilience to weather-related shocks, enhance the nutritional value of crops, and ensure food safety will also be critical. Speaking on this topic will be Dr Shenggen Fan, Director General of the International Food Policy Research Institute (IFPRI) since 2009. For more information visit:

www.teagasc.ie/events/rds-lecture-series/index.asp

May

29 May

Training Centre, Teagasc Food Research Centre, Ashtown Dublin 15

Understanding consumers from an industry, policy and practice

perspective

A one-day seminar on consumer food behaviour is being hosted by Teagasc in partnership with UCC and safefood. The seminar will focus on environmental, social and personal influences on food related behaviour with a host of national and international speakers from both industry and academia. This seminar is suited to those who would like to develop a deeper understanding of consumer food behaviour in relation to health policy, new product development and research. For further information, contact Sinéad McCarthy: 00353 (0) 1 8059962; sinead.mccarthy@teagasc.ie

June

23 - 26 June

UCD, Dublin

Greenhouse Gases & Animal Agriculture Conference (GGAA 2013)

The conference is being organised by Teagasc and University College Dublin. This scientific meeting will attract speakers and delegates from throughout the globe and builds on previous successful meetings in the series. The meeting will focus on advancements in the areas of animal derived GHG mitigation since the last meeting in Banff, 2010. Some financial support is available to help participation by delegates from least developed countries. Conference Sessions include:

- Policy and industry context for greenhouse gases from animal agriculture
- Techniques for measuring greenhouse gases – enteric methane, soil and manure-derived gases
- Microbiology of the rumen, soil and manure in relation to greenhouse gas emissions
- Mitigation strategies - enteric methane, soil and manure-derived gases
- Modelling of livestock greenhouse gas emissions

Conference website: www.ggaa2013.ie; Scientific queries: Richard.dewhurst@teagasc.ie; Registration queries: ggaa2013@conferencepartners.ie

July

3 July

Animal & Grassland Research and Innovation Centre, Moorepark, Fermoy, Co. Cork

Moorepark'13 Irish Dairying: Countdown to 2015

World demand for dairy products is expected to increase further, due to global population growth and increases in per capita disposable income especially in developing countries. The abolition of milk quotas in 2015 gives many dairy farmers scope to increase milk production for the first time in 30 years. To ensure success, dairy farmers must be able to plan, finance and deliver expansion, while at the same time confront issues such as volatility in milk price and difficult weather conditions, like that experienced in 2012. Expansion in the dairy farm business should only be undertaken if it increases profit and provides a better lifestyle to the farm family. When EU milk quota is abolished farm profitability will be dependent on maximising profit per hectare, i.e., stocking your farm to match grass supply. This major Open Day will provide the roadmap to deliver these goals for the Irish dairy industry. For further information please contact Ms Margie Egan: 00 353 (0)25 42292; margie.egan@teagasc.ie

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