European Plant Science Organisation

The European Association for Bioindustries

Discussion Document

"Plants for the Future – a National e-Consultation on Priorities & Opportunities for Plant Research in Ireland & Europe"

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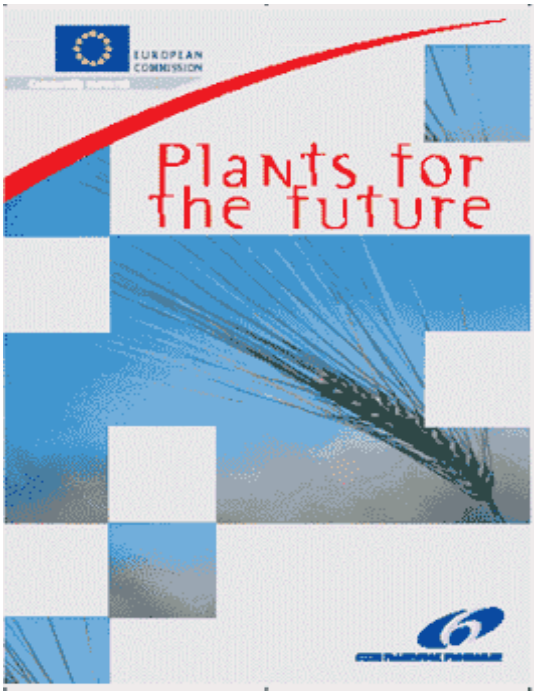

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Executive Summary

"Plants for the Future" Background

The European Union Member States agreed at the Lisbon Summit (2000) to make the EU "the most competitive and dynamic knowledge-driven economy by 2010". EU Member States have made a commitment to increase research investment from the current level of 1.9% of GDP to 3% of GDP by 2010, of which 2/3 should be funded by the private sector.

In line with overall, EU strategy, Ireland's research investment targets are outlined in " Building Ireland's Knowledge Economy - The Irish Action Plan for Increasing R&D to 2010 ", and include increasing R&D spending to 2.5% of GNP by 2010 from its current level of 1.4%, and entail a significant commitment to R&D investment from industry across all sectors, including plant research.

The key instruments for achieving the EU targets are Technology Platforms, which will bring together the main stakeholders around key technologies in order to devise and implement a common strategy for the development, deployment and use of technologies.

The "Plants for the Future" Technology Platform" brings together relevant stakeholders: researchers, policy-makers, environmental and consumer groups, industry and farmers to:

- refine a research vision for plant science in Europe
- identify strategic priorities for plant research in Europe
- define and support the implementation of a coherent and dynamic research agenda for plant science in Europe

By October 2005, two key outputs had been generated by the Plants for the Future platform:

- The Strategic Research Agenda (SRA) – which outlines research priorities for the next 20 years (2005-2025)

Action plan – which details research endeavours in European plant research for the 2006-2010 period

In late 2005, consultations with relevant stakeholders on the "Plants for the Future" proposal were conducted across all 22 EU Member States, including Ireland. For the national consultation in Ireland, it was decided that an electronic-survey (e-survey) approach would be the fastest and most efficient way to obtain inputs from a wide range of Irish stakeholders on the Plants for the Future Platform SRA & Action Plan. It was also decided to use the e-survey to obtain an overview of:

a) the extent of plant research underway in Ireland (of potential relevance to the proposed Technology Platform).

b) the types of plant research underway or planned in Ireland.

c) opportunities and constraints facing the plant research community in Ireland.

The results of this questionnaire have been collated into a national discussion document on plant research, and are being provided as an input to the finalisation of the Plants for the Future SRA & Action Plan, which is expected to be an integral component of future Framework 7 activities in plant research. It is also intended that the document can act as a reference or briefing document on plant research (related to the Technology Platform) in Ireland as of late 2005.

Background to the National Consultation

The purpose of the 2005 National Consultation on "Plants for the Future" is to provide a broad input for the finalisation of the Strategic Research Agenda (SRA) of the Technology Platform for European Plant Science, and also to determine the level of interest and support of Irish stakeholders for the implementation of the Strategic Research Agenda & Action Plan for European plant research.

The “Plants for the Future” Research Agenda and Action Plan will address four major challenges:

- Challenge one: Healthy, safe and sufficient food and feed
- Challenge two: Sustainable agriculture, forestry and landscape
- Challenge three: Green products
- Challenge four: Competitiveness, consumer choice and governance

This report is the output of the National Consultation based on the replies and inputs obtained from the e-survey, and are currently the best approximation of key Irish stakeholders’ national position/inputs regarding the Strategic Research Agenda & Action Plan. This report also includes an assessment of the level of interest and support in Ireland for the SRA's objectives and actions, and possible recommendations for amendments or re-prioritisation.

Sectors, stakeholders and respondents to e-survey

A database of ~800 stakeholders in Ireland considered relevant to the research activities proposed in the SRA was composed. The stakeholders to be surveyed were grouped into the following institutional sectors:

- University & Institutes of Technology (~222 contacted, 47 responses)
- Government (~ 208 contacted, 28 responses)
- Industry & Private Sector (~303 contacted, 22 responses)

- NGOs & civil society organisations (~28 contacted, 4 responses)

Each of these stakeholders was sent an e-mail providing a link to the e-survey questionnaire[1] requesting stakeholders' perspectives and inputs for plant research in Ireland/Europe. The deadline was 31st October 2005. It was indicated this discussion document (resulting from this consultation) would be circulated to all stakeholders contacted.

There were 101 complete responses to the e-survey obtained from the over 800 stakeholders contacted (response rate ~10%). All stakeholders contacted were of direct relevance to plant research and development in Ireland.

National Consultation Key Findings

European Plant Research Strategy

Over 90% of the respondents (n=98) indicated that there is a need for a European Plant Research Strategy 2010-2025. While there was strong support from the respondents regarding the importance of all four challenges (see above) for plant research in Europe, the strongest support were for sustainable agriculture (99%) and securing a healthy/safe food supply (98%), while green & pleasant land (88%) and competitiveness/consumer choice (83%) has less support from the respondents. The detailed responses of the respondents in terms of plant research priorities and plant research underway in Ireland are contained in the longer Discussion Document.

Plant research capacity in Ireland.

The survey indicated that while 27-32% of respondents felt there was sufficient research capacity in Ireland to meet the four challenges, an approximately equal proportion 22-33% felt that research capacity in Ireland was insufficient to address the four challenges. However, the largest category of respondents (35-48%) did not know whether there was sufficient research capacity in Ireland to address the four challenges. This indicates that there is currently no consensus on whether Ireland has sufficient research capacity for plant research, either across or within the major stakeholder sectors. This suggests a need for greater research coordination and communication to ensure that existing and future plant research capacity is better understood in terms of its relevance to Irish society and economy.

Plant research capacity in Ireland is currently very low and fragmented across universities and research institutes such as TEAGASC. Research teams are small and there are no teams of critical mass established. The historical underfunding of plant R & D in Ireland has led to a situation where the research infrastructure for plant research particularly in

[1] The e-survey questionnaire could be accessed by clicking <<http://www.surveymonkey.com/s.asp?u=389611379212>> or copying this URL into the browser window.

the universities is crumbling and in need of major modernisation. Over the past decades, the lack of strategic funding for improving the quantity, quality and relevance of plant R & D in Ireland has prevented Ireland from developing sufficient research capacity to impact on these challenges.

Prioritising the four Plants for the Future challenges

The stakeholders were asked what priority the four challenges are for plant research in Ireland & the European Union. In general, there was a significant level of concordance between the priorities for Ireland and the European Union. The stakeholders were also asked whether there were any challenges omitted that should be included for Irish or European plant research. This was difficult for stakeholders to answer unless they had read the SRA in detail and hence some proposed omissions are actually contained in the SRA & Action Plan. Based on the four challenges as presented to the respondents early in the questionnaire, it is clear that bioenergy and novel products are considered important challenges for plant research in both Ireland and EU. Other topics considered important challenges by at least four different respondents were biomedicine, sustainability and conservation, climate change, basic research and biosafety.

Challenge 1: To develop and safe and sufficient food & feed.

Crop plants are the basis for our food and feed and in this context there is undoubtedly no other single biological system upon which mankind is as much dependent as crop plants. Between 92% of respondents agreed that all three goals for Challenge 1 (to develop and safe and sufficient food & feed) were desirable, namely:

Goal 1.1: Develop and produce safe and high-quality food (92% in favour). Both safety and quality of food is essential and determined by different characteristics. Plant raw material for food and feed need to contain certain main components (carbohydrates, proteins and oils) in desirable amounts, as well as all the factors influencing its nutritional value.

Goal 1.2: Create food products targeted at specific consumer groups and needs (93% in favour). Food can do more than meet our basic nutritional need. Some food components can actively supporting our general health and well-being. Good examples of this are plant-derived phytosterols which are added as an ingredient of some margarines. Regular consumption of this kind of margarine reduces blood cholesterol levels which lower the risk of coronary heart disease. For this reason, the Strategic Research Agenda also focuses on developing plant raw materials for healthier/functional foods.

Goal 1.3: Produce safe, high quality, sufficient and sustainable feed (95% in favour). Over the past two decades, global meat production has increased rapidly. The European Union imports some 40 million tons of grain each year – 70% of these protein-rich compounds are used as feed. In addition to boosting production, safety is likely to remain a crucial issue when it comes to feed. In this context, the reduction of mycotoxins –

caused by fungus – in cereals will play a prominent role. The better we understand the feed requirements of cattle, swine and poultry on a molecular level, and the better we adapt feed to them, the higher meat quality will become.

Overall, for Challenge 1 there is a significant level of relevant research underway in specific research groups which are spread across universities and research institutes in Ireland. Given the national emphasis on functional foods as a strategic area for R & D, there is considerable potential for plant research to contribute to this area.

Functional Foods in Ireland

Stakeholders were asked whether plant research should be part of an R&D strategy for functional foods in Ireland. Over 90% of respondents indicated that they felt that plant research should be part of a national R& D strategy for functional foods in Ireland, and also a part of any European level R& D strategy for functional foods.

Plants and public health in Ireland

The respondents were asked should plant research be used to develop healthier foods and diets. 92.6% of respondents indicated that plant research should be use to develop healthier food and diets.

Challenge 2: Sustainable agriculture, forestry and landscape.

Over the next 20 years (2005 to 2025), the challenge is not only to satisfy growing demand for food, fibres and fuel but also to do it in a sustainable manner. This sustainability challenge will focus on the following four goals for which there is broad support amongst the respondents.

Goal 2.1: Improve plant productivity and quality (99% in favour). We need to strike a sound balance between boosting productivity and providing consumers with the products and quality they require. Part of the answer lies in plant genomics – understanding how all the inherited characteristics of a plant combine to imbue it with its intrinsic characteristics. Plant genomics can also help manage natural resources and biodiversity optimally.

Goal 2.2: Reduce and optimise the environmental impact of agriculture (86% in favour). A second sustainability priority is to reduce the environmental impact of agriculture. Europe is the cradle of plant breeding and plant biotechnology, and has the potential to meet these challenges and create more sustainable cropping systems by combining genomic approaches with analytical techniques, molecular breeding and biodiversity studies.

Goal 2.3: Boost biodiversity (88% in favour). The third sustainability priority should be to enhance and utilise plant biodiversity. Part of our existing biodiversity lies in the collections of plant varieties and related species in gene banks. These have served as the

sources for many crop improvements. However, hundreds or thousands of stored seeds with potentially useful properties have never been explored. We now have the tools to look for the genetic biodiversity hidden in those collections. In addition, the domestication of new plant varieties would greatly increase biodiversity within agriculture.

Goal 2.4: Enhance the aesthetical value and sustainability of the landscape (92% in favour). Land should no longer be viewed solely as a production silo, but rather as complex interconnecting networks and reservoirs of natural resources, which can be used for human benefit without long-term damage to the biodiversity that underpins all systems.

Overall for Challenge 2 there is significant interest in the proposed R & D, and also some research activities on plant biodiversity, plant genetic resources, forestry and ornamentals underway that are relevant to Challenge 2.

Challenge 3: Green Products

As oil supplies further decrease, security as well as cost becomes an issue, and a worldwide chemical industry dependent on petrochemical feedstocks must seek alternative sustainable supply chains. Part of the solution can be provided by tapping into the raw materials provided by green plants. Plants manufacture simple sugars that are converted in the pathways of primary and secondary metabolism into a vast array of complex chemicals: carbohydrates, oils, proteins, and other products. Plants can provide cost-effective biorenewable feedstocks for sustainable supply chains – fuelled by the sun and dependent only on the manufacturing capacity of the living cells that make up the 'plant factory'. These supply chains would feed the global chemicals industries, but also include pharmaceutical manufacturers. This area is particularly relevant given that the EU aims to extract 20% of the raw materials for transport energy from plants. This challenge focuses on two main goals (with associated sub-goals):

Goal 3.1: Plants as a basis for renewable resources

> **Goal 3.1.1: Improving the efficiency of existing industrial crops and the utility of their products (99% in favour).** Plants are already cheap renewable factories for the production of many raw materials and chemicals of considerable value to a wide range of non-food sectors. These existing crops and their products can be improved. This improvement relates to the quantity and quality of the raw materials, as well as the post-harvest use of those materials in the supply chains of the different industrial sectors
>
> **Goal 3.1.2: Expanding the quality of raw materials and product range of industrial crops – new plant-based raw materials with widened utility (96% in favour).** By gaining a greater understanding of how plants function, particularly in terms of their development, metabolism and the impact of the

environment on these processes, new opportunities for altering the range of products plants manufacture are likely to emerge.

Goal 3.2: Plant-based pharmaceutical and diagnostic products (96% in favour). Plants already represent a valuable resource for natural medicinal products, as well as in the production of pharmaceuticals. This plant-based renewable resource is set to increasingly underpin the future of medicine – as a source of natural medicinal products and as a source of medicinal proteins for pharmaceuticals. It is essential to improve the efficiency of plant production and industrial use of existing medicinal products, as well as to expand the product range, both through building on the plant's own metabolic pathways and through the use of the plants in GM applications to make therapeutic proteins and vaccines. In addition, plants have a largely untapped potential for mass-producing diagnostics competitively, and for the monitoring and bioremediation of environmental pollutants.

There is a dispersed set of research groups in Ireland conducting research on bio-pharming and phyto-extraction which are areas of direct relevance to Challenge 3.

Plant-based biofuels & bioenergy

Over 92% of respondents indicated that plant-based bioenergy should play a role in meeting Ireland's future energy needs. When asked whether there should be increased funding for research on plant-based bioenergy in Ireland, 92% of respondents (n=89) indicated that there should be. The survey recipients were also asked whether there is a need for a National Multi-stakeholder Research Initiative on Plant-Based Bioenergy in Ireland. Over 77% of respondents (n=88) indicated that there was a need for such an initiative, while 3.4% said there was not a need, and over 19% or respondents did not know.

Challenge 4: Competitiveness, consumer choice and governance.

The successful implementation of the objectives outlined in the previous three challenges of this Strategic Research Agenda depends on a strong European research and resource base: vibrant basic research, skilled and mobile researchers, and access to key research infrastructures. Vibrant basic research is essential for EU competitiveness, and the Technology Platform's sustainability, innovation, and consumer choice goals are critically dependent on knowledge, tools and technologies derived from basic research. The Technology Platform intends to focus on a number of goals (& associated sub-goals) to meet the issues in this challenge:

Goal 4.1: Vibrant basic research. The cutting edge of basic plant research is rapidly evolving from understanding the function of single genes to more "holistic" approaches studying networks of genes that control biological processes. This new era of integrative biology enables us to determine how the interconnected networks of genes work together in complex biological processes, how natural genetic variation creates biodiversity.

Goal 4.1.1: Genome sequencing and biodiversity (95% in favour). Genome sequences are one of the primary frameworks furnishing basic knowledge of a species.

Goal 4.1.2: Undertake plant systems biology (95% in favour). There are currently efforts underway to establish a large scale Systems Biology Initiative in Ireland. Plant systems biology aims to understand how multiple genes function in concert to affect key processes in plant development and environmental interactions, metabolism and physiology.

Goal 4.1.3: Develop improved research tools & processes (94% in favour). The development of new improved research tools and processes is necessary as it has been shown that advances in biotechnology and genomics are strongly driven by technological innovation.

Goal 4.1.4: Develop improved genetic systems for crop improvement (88% in favour). Develop improved genetic systems for crop improvement, as systems biology research into basic biological processes in model species should be translated to relevant traits in key crops by delineating the molecular basis of genetic systems underpinning crop improvement and innovative agricultural practices.

Goal 4.2: Human resources, infrastructure and networking (99% in favour). Rapidly evolving fields of science and technology are typically driven by the best young and talented scientists. The proper nurturing of young and talented scientists through training and mobility opportunities is a critical success factor for the competitiveness of plant research in Europe.

There is no inter-institutional National Graduate School in Plant R & D that would effectively harness all of the dispersed expertise in plant research in Ireland in order to deliver advanced plant research training to postgraduate researchers. The plant researcher community in Ireland is fragmented and isolated from its counterpart communities both in the UK and mainland Europe. Unless Ireland's universities and funding bodies make a concerted effort in terms of funding, coordination and planning, Ireland will continue to entrench itself towards an incredibly weak position in advanced plant research.

Capacity for Coordination of Plant R & D in Ireland. Coordination is crucial to the global competitiveness of the European research effort and to achieve the critical mass of resources needed for the realisation of the ambitious goals of the Technology Platform by overcoming the current fragmentation and duplication. This coordination is required at three different levels: between research institutions, between academia and industry and at the international level. At all levels in Ireland, such coordination ranged from low to medium, with the highest proportion of respondents unable to opinion whether coordination was sufficient or not at the different levels (Figure 10).

Goal 4.3: Public and consumer involvement (93% in favour). A large proportion of the Technology Platform's activities will be devoted to engagement with the public. Each

technical programme will have a mechanism that not only provides information but, where possible, allows the public to engage with and influence the course of events.

Goal 4.4: Ethics, safety, legal and financial environment (92.9% in favour). The Technology Platform proposes to improve dialogue and actions around ethics and considerations and actions leading to a legal and regulatory environment providing for safety, consumer choice, coexistence of different farming practices and intellectual property rights, and a financial environment encouraging entrepreneurs and industry to invest in plant science research and development.

Intellectual Property Rights & Plant Research

The Irish Council for Science Technology & Innovation recently developed a National Code of Practice for Managing Intellectual Property from Publicly Funded Research. The Code addresses each aspect of the management and transfer of research and development results from universities, institutes of technology and public research institutions to the commercial market place. While almost 70% of plant research respondents were aware of the National Code, over 30% were unaware of it. The respondents were further asked whether they had read the National Code of Practice for Managing Intellectual Property from Publicly Funded Research. Only 14.1% indicated that they had read the Code, while 85.9% indicated that they had not read the Code.

The respondents were asked whether the outputs of publicly-funded plant research in Ireland should be protected by intellectual property rights (e.g. patents, plant breeders' rights, trademarks, copyright). For this question, 56.5% of respondents (n=85) were in support of the outputs of publicly-funded plant research being protected by intellectual property right, while 32.9% were not in support and 10.6% were unsure.

The respondents were also asked whether the outputs of privately-funded plant research in Ireland should be protected by intellectual property rights (e.g. patents, plant breeders' rights, trademarks, copyright). For this question, 72.9% of respondents (n=85) were in favour of the outputs of privately-funded plant research being protected by intellectual property right, while 14.1% were against and 12.9% were unsure.

Plant Research and Developing Countries

Ireland has had an official development assistance programme since 1974. It has grown steadily over the years from modest beginnings to its current size (total Overseas Development Aid (ODA) in 2005 is 545 million euros). Since its inception in 1974, the Development Cooperation Ireland (DCI) programme has had a strong geographic focus on Sub-Saharan Africa, namely Lesotho, Mozambique, Tanzania, Ethiopia, Zambia and Uganda. These are termed "Programme Countries".

The respondents were asked whether Ireland should support plant research partnerships for poverty reduction in Ireland's Programme Countries. Of the 84 respondents to this question, 92.9% were in favour of Ireland supporting plant research partnerships for

poverty reduction in Ireland's Programme Countries, while 1.2% was against this and 6% were unsure.

Ireland has an objective to contribute 0.7% of GDP to overseas development aid by 2013. The Irish Government has allocated 2500 million euros for Research, Technology and Innovation activities in the National Development Plan (2000-2006).

Respondents were asked whether Ireland should spend 0.7% of its overall plant R & D expenditure on plant research of relevance to its Programme Countries in Africa. For this question, 71.8% of Respondents (n=85) indicated their support of the proposal that Ireland could spend 0.7% of its overall plant R & D expenditure on plant research of relevance to its Programme countries in Africa, while 8.3% were not in support of this idea and 20% were unsure.

The respondents were asked whether Ireland should contribute financially to initiatives that increase collaboration between researchers in Ireland's partner countries and Irish plant researchers. Of the 85 respondents to this question, 89.4% agreed that Ireland should contribute financially to initiatives that increase collaboration between researchers in Ireland's partner countries and Irish plant researchers, while 2.4% disagreed and 8.2% were unsure.

National Capacity for Plant Research in Ireland.

The advanced plant research capacity in Ireland of relevance to the Plants for the Future Technology Platform is currently fragmented across multiple universities and government research institutions (e.g. TEAGASC).

There are at least 30+ research groups/labs in Ireland working on plant genetics & biotechnology (basic, agricultural, forestry, algae, ecology, biodiversity, genetic resources, nutrition, and pharmacological), including genomics, genetics, breeding, molecular biology, natural products chemistry and metabolomics.

In other countries with a similar distribution of plant research capacity, there have been successful initiatives to pool existing plant (or other) research expertise under the common umbrella of a National Platform and thereby assemble critical research mass. Examples of national research & training 'platforms' include:

- Zurich-Basel Plant Science Center (3 universities, 1 research institute, 20+ research groups)
- Plant Science Scotland
- Virtual Institute of Bioinformatics Eire (VIBE) – (11+ research groups)
- Ireland's National Platform for Biodiversity Research – (forum for dedicated funding windows for biodiversity research in Ireland)
- Dublin Molecular Medicine Center (DMMC) – (3 universities, 6 hospitals)
- Flanders Interuniversity Institute for Biotechnology - (850 scientists, 4 universities)

National Multi-stakeholder Platform/Coalition for Plant Research in Ireland.

The respondents were asked whether there is a need for a National Multi-stakeholder Platform/Coalition for Plant Research in Ireland. Of the 82 respondents who answered this question, 76.8% of Respondents agreed that there was a need for a National Platform for plant research in Ireland, while 23.2% were unsure. There were no respondents opposed to the development of a National Multi-stakeholder Platform/Coalition for Plant Research in Ireland.

The respondents were asked to rank the relative importance of a range of objectives in the event of a National Platform. Overall, the majority of respondents indicated their support for different objectives for the creation of a National Platform for plant research. This level of support ranged from 57%-83% with the specific levels of support for each objective highlighted in Figure 11.

Overall recommendations/findings

1. The majority (consistently over 90%) of respondents were in support of all of the challenges and goals presented for the Plants for the Future technology Platform (TP), Strategic Research Agenda (SRA) and Action Plan.

2. At present, there seems to be little consensus amongst stakeholders on whether Ireland has sufficient research capacity in advanced plant research and development to meet its future needs.

3. Advanced plant research capacity in Ireland (of relevance to the Plants for the Future TP) is currently very low and fragmented across universities and research institutes such as TEAGASC.

4. Lack of strategic funding & planning for improving the quantity, quality and relevance of plant R & D in Ireland has prevented Ireland from developing sufficient plant research capacity to impact on the national economy and society.

5. There is potential and support amongst stakeholders for the establishment of a National Multi-stakeholder Platform/Coalition for Plant Research in Ireland.

6. Plant research should be an integral part of any R&D strategy for functional foods in Ireland and Europe.

7. There is a need for a National Multi-stakeholder Research Initiative on Plant-Based Bioenergy in Ireland.

8. There is a need for an inter-institutional National Graduate School in Plant R & D that would effectively harness all of the dispersed expertise in plant research in Ireland in order to deliver advanced plant research training to postgraduate researchers.

9. There is strong support for plant research oriented to meeting needs in Ireland's bilateral aid partner countries (e.g. in Sub-Saharan Africa).

Introduction

The European Union Member States agreed at the Lisbon Summit (2000) to make the EU "the most competitive and dynamic knowledge-driven economy by 2010". This ambition will require a stronger research base within the EU and concerted efforts to make European science more attractive to private investment in research and innovation.

To fulfil this ambition, EU Member States have made a commitment to increase research investment from the current level of 1.9% of GDP to 3% of GDP by 2010, of which 2/3 should be funded by the private sector. This commitment is one of a series of actions outlined in the European's Commission's Action Plan entitled "Investing in research: an Action plan for Europe." (COM(2003) 226).

The key instruments for achieving these targets are Technology Platforms, which will bring together the main stakeholders around key technologies in order to devise and implement a common strategy for the development, deployment and use of technologies

The "Plants for the Future" Technology Platform" brings together relevant stakeholders: researchers, policy-makers, environmental and consumer groups, industry and farmers to:

- refine a research vision for plant science in Europe
- identify strategic priorities for plant research in Europe
- define and support the implementation of a coherent and dynamic research agenda for plant science in Europe

Throughout 2005, consultations with relevant stakeholders on the "Plants for the Future" proposal were planned across all 22 EU Member States. In February 2005, Dr. Charlie Spillane (SFI Investigator, UCC) was asked to act as the Irish National Representative for the European Plant Science Organisation and to coordinate a consultation process amongst Irish stakeholders on the Plants for the Future Technology Platform.

By October 2005, two key outputs had been generated by the Plants for the Future platform:

- The Strategic Research Agenda (SRA) – which outlines research priorities for the next 20 years (2005-2025)
- Action plan – which details research endeavours in European plant research for the 2006-2010 period

In order to reach as many stakeholders in as short a time-frame as possible it was decided that an electronic-survey (e-survey) approach would be the fastest and most efficient way to obtain inputs from a wide range of Irish stakeholders on the Plants for the Future Platform SRA & Action Plan. It was also decided to use the e-survey to obtain an overview of:

a) the extent of plant research underway in Ireland (of potential relevance to the proposed Technology Platform).

b) the types of plant research underway or planned in Ireland.

c) opportunities and constraints facing the plant research community in Ireland.

Hence an e-survey questionnaire was devised which aimed to consult with key stakeholders in Ireland to provide inputs and priorities for both European & domestic plant research. The questionnaire allowed respondents to provide inputs on what they and their colleagues consider to be the main priorities for European Plant research, particularly from an Irish perspective. The short time-frame available for consultation with Irish stakeholders meant that an e-survey was the best approach to take in the first instance, followed by a series of thematic workshops (with some planning objectives) throughout 2006 & 2007 across the various research institutions, on topics highlighted to be of importance by the stakeholder respondents.

This document now collates the results of this questionnaire into a national discussion document on plant research, and is being provided as an input to the finalisation of the Plants for the Future SRA & Action Plan, which is expected to be an integral component of future Framework 7 activities in plant research. It is also intended that the document can act as a reference or briefing document on plant research (related to the Technology Platform) in Ireland as of 2005.

Background to the National Consultation

Ireland is committed to working closely with the European Commission to increase investment in plant research & development (R&D) that supports social and economic objectives. Ireland's research investment targets are outlined in " Building Ireland's Knowledge Economy - The Irish Action Plan for Increasing R&D to 2010 ", and include increasing R&D spending to 2.5% of GNP by 2010 from its current level of 1.4%, and entail a significant commitment to R&D investment from industry across all sectors, including plant research.

The purpose of the 2005 National Consultation on "Plants for the Future" is to provide a broad input for the finalisation of the Strategic Research Agenda (SRA) of the Technology Platform for European Plant Science, and also to determine the level of interest and support of Irish stakeholders for the implementation of the Strategic Research Agenda & Action Plan for European plant research.

The “Plants for the Future” Research Agenda and Action Plan will address four major challenges:

- Challenge one: Healthy, safe and sufficient food and feed
- Challenge two: Sustainable agriculture, forestry and landscape
- Challenge three: Green products

- Challenge four: Competiveness, consumer choice and governance

This report is the output of the National Consultation based on the replies and inputs obtained from the e-survey, and are currently the best approximation of key Irish stakeholders' national position/inputs regarding the Strategic Research Agenda & Action Plan. This report also include an assessment of the level of interest and support in Ireland for the SRA's objectives and actions, and possible recommendations for amendments or re-prioritisation, taking into account specific national circumstances, such as the specific role of the industrial, agricultural or other sectors in Ireland and the expertise/capacity & perspectives of its plant research community.

Sectors, stakeholders and respondents to e-survey

A database of ~800 stakeholders in Ireland considered relevant to the research activities proposed in the SRA was composed. The stakeholders to be surveyed were grouped into the following institutional sectors:

- University & Institutes of Technology (~222 contacted, 47 responses)
- Government (~ 208 contacted, 28 responses)
- Industry & Private Sector (~303 contacted, 22 responses)
- NGOs & civil society organisations (~28 contacted, 4 responses)

Each of these stakeholders was sent an e-mail providing a link to the e-survey questionnaire[2] requesting stakeholders' perspectives and inputs for plant research in Ireland/Europe. It was indicated that an objective was to determine research capacity, priorities, opportunities & needs for plant research in Ireland. It was also highlighted that the consultation was intended to provide an opportunity for stakeholders and their colleagues to provide inputs on what they considered to be the main needs & priorities for plant research directions and funding in Europe, particularly from an Irish perspective.

The major purpose of the e-survey was to provide feedback from Irish stakeholders on the Strategic Research Agenda (SRA) and draft Action Plan devised by the "Plants for the Future" Technology Platform. It was indicated that the deadline for completion of the questionnaire was the *31st of October, 2005*. It was also indicated that this discussion document (resulting from this consultation) would be circulated to all stakeholders contacted.

Response rate to the e-survey & disaggregation of respondents

There were 101 complete responses to the e-survey obtained from the over 800 stakeholders contacted (response rate ~10%).

[2] The e-survey questionnaire could be accessed by clicking <<http://www.surveymonkey.com/s.asp?u=389611379212>> or copying this URL into the browser window.

Where indicated, 71% of respondents were male & 29% were female (n=84), indicating that there is a gender bias towards males in the response to the e-survey on plant research in Ireland.

Female respondents were mostly employed as postgraduate students (6%, n=84) or as lecturers (7%, n=84), with few progressing onto professor level. There were no female respondents employed as CEOs. Male respondents were primarily employed as or professors (14%, n=84) or research managers (12%, n=84).

The vast majority of respondents (n=70) were of Irish nationality (77%), with the remaining nationalities being British (9%), French (3%), German (4%), Polish (3%), Spanish (3%) and Italian (1%).

Where indicated, Irish respondents were largely employed as professors, lectures or research managers (8% per sector, n=72) with a considerable number of responses from Masters and PhD students (6% per sector, n=72). UK respondents are principally employed as professors (6% per sector, n=72). The remaining nationalities were Masters and PhD students or Post Docs.

The age profile of respondents (n=84) indicated that the majority of respondents were in the 40-49 year old range, but that there were significant numbers of respondent from all the other age ranges as well (Figure 1).

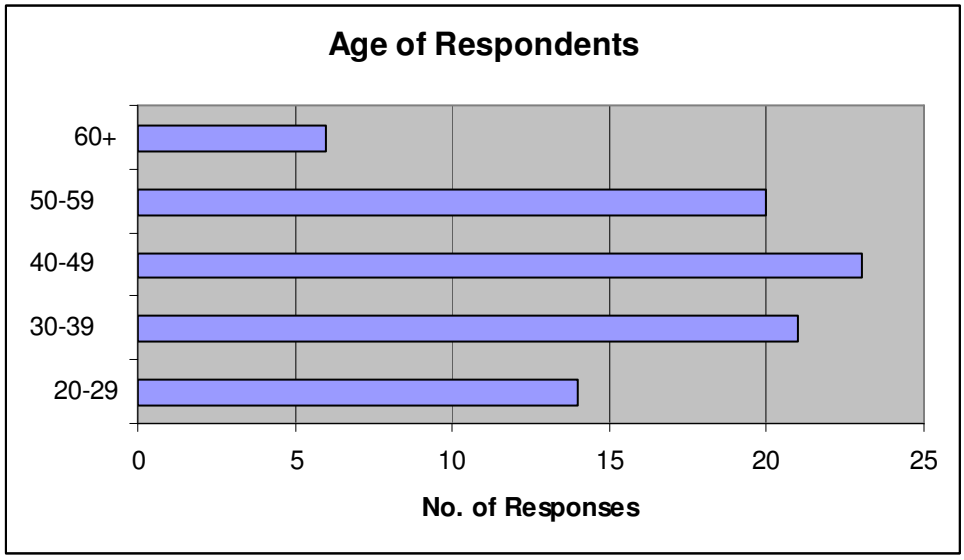


Figure 1: Age profile of respondents.

A sectoral breakdown of the respondents showed that 48% of the 101 respondents were from the academic sector, 29% from government institutions and 23% from industry. An approximately equal number of stakeholders were contacted within the different sectors.

The responses from the industrial sector were classified into different sizes/scales of enterprises (n=28), with a good distribution of responses from microenterprises (21%), small enterprises (11%), medium enterprises (14%), large companies (18%), self-employed (18%) and others (Figure 2).

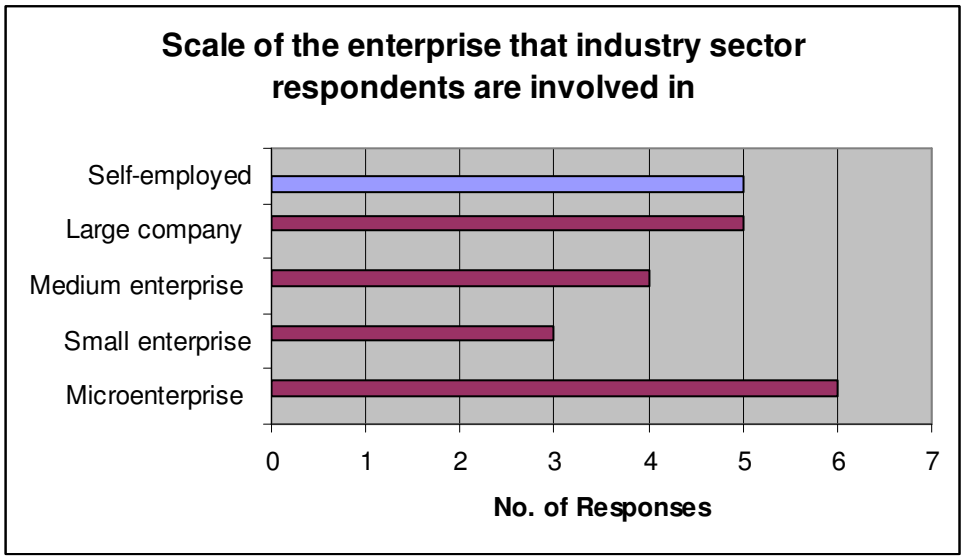


Figure 2: Profile of size and scale of the enterprises involving industry sector respondents.

There was a limited response from the NGOs and civil society groups contacted, with bodies representing farmers and producers constituting 29% of the 7 respondents in this category. The remaining respondents in this sector were in the energy sector, the retail grocery sector and in the biomedical research sector. All respondents in this sector were however non-governmental and non-private sector.

The respondents represented a broad swathe of job levels/positions (n=84) ranging from CEOs of companies & Professors in universities, to MSc & undergraduate students (Figure 3).

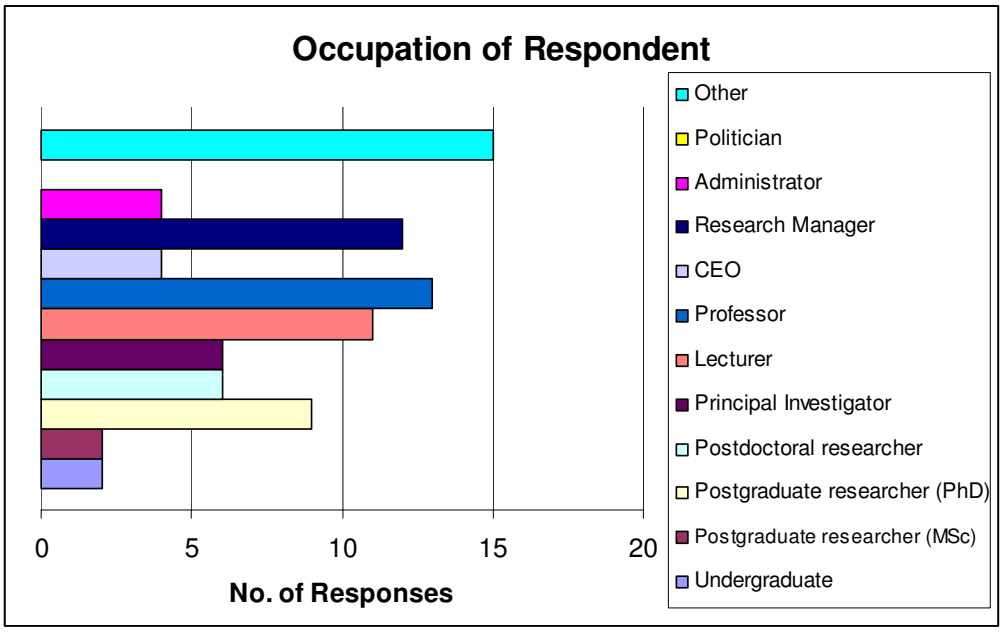


Figure 3: Responses from stakeholders on their current occupations (n=84). "Other" responses include: Programme manager, Journalist, Regulator (2x), Business Manager, Agricultural Inspector, CEO owner (2x), Director (2x), Research Analyst, Policy analyst (2x), Communications manager and Research Associate.

The respondents indicated how many people were working on plant-related research activities in their research group or office. Over half (52%) of all respondents (n=67) represented situations where 1-4 people were working on plant related research, while 32% consisted of teams of 5-9 people and 9% represented 10-14 people. The presence of larger research teams or offices in plant related research is rare in Ireland with only 5% of respondents working in teams of 15-19 people, and only 2 respondents (3%) indicated that they worked in plant research situations composed of 20 or more people (Figure 4).

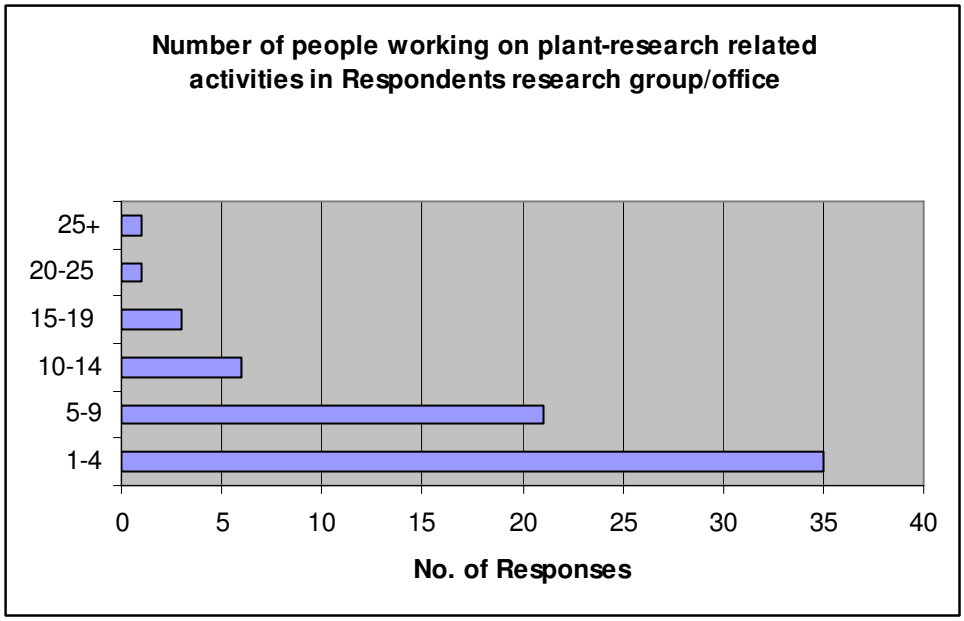


Figure 4: Number of researchers working on plant-related research in the research groups or offices of the respondents.

The majority of the survey respondents (67%) were involved in research with the remainder of respondents involved in administrative (21%) and governing/regulatory roles (12%). Of the respondents directly involved in plant research, 63% were from the university/IT sector while 20% were in government sector & 17% in industry sector. The vast majority of respondents from the university & IT sectors were involved in plant research (87%) while approximately half of the respondents from the government (46%) & industrial (50%) sectors were involved in plant research. This indicated that significant levels of plant research are underway in all of the three sectors, with a possibly higher level underway in the university/IT sector (Appendix 1).

Research topics and areas of the respondents

The majority of the 101 respondents indicated they were involved in plant and botanical research (40%), followed by food and nutrition (13%) and chemistry/biochemistry (11%). The remaining plant researcher respondents were working on energy (6%), genetics and proteomics (6%), economics (6%), bioethics (4%), horticulture (4%), and forestry (4%). The remainder (4%) of respondents marked other as their area of research which included microbiology, ecology & agronomy, environmental science, and agricultural & environmental meteorology. See Figure 5.

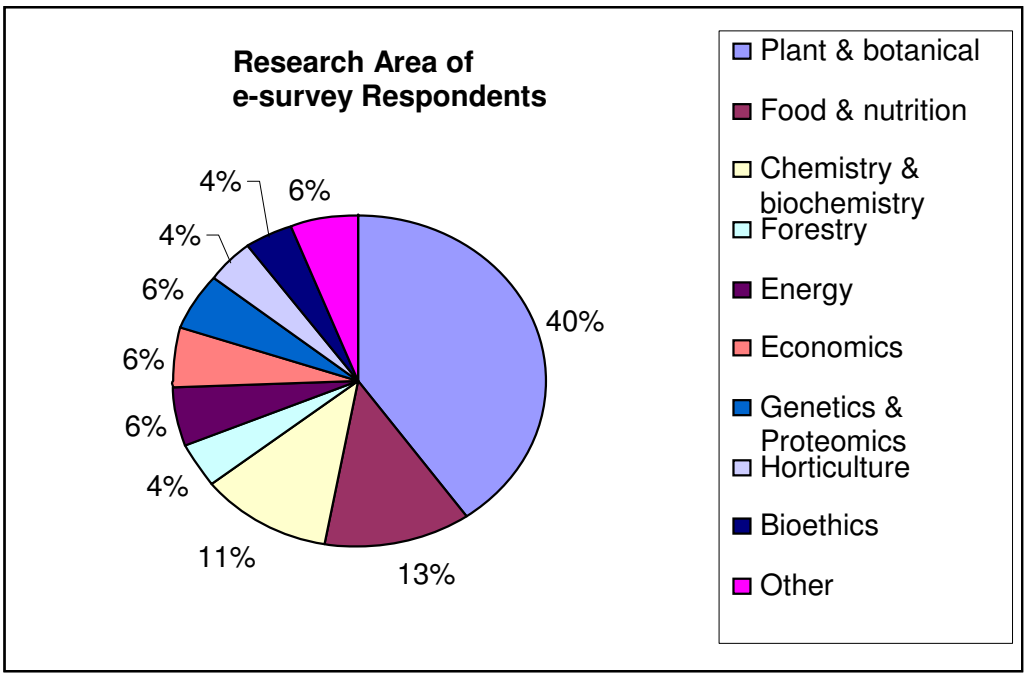


Figure 5: Research areas indicated by respondents to the national e-survey consultation. The category other is comprised of microbiology, ecology & agronomy environmental science, agricultural & environmental meteorology.

Plant Research Strategy, Challenges, Capacity & Priorities

Need for a European Plant Research Strategy 2010-2025?

Over 90% of the respondents (n=98) indicated that there is a need for a European Plant Research Strategy 2010-2025. Only 2 respondents responded that there was no need for such a strategy. The reason given by one of these respondents was that it should include ecology and management of semi-natural ecosystems.

The draft SRA consisted of four main challenges for European plant research:

Research Challenge 1: Securing a healthy and safe food supply. Improving living standards, particularly in developed countries, and a growing world population are rapidly boosting global demand for high quality and safe food. Food shortages and famines are currently localised phenomena and can be addressed by improving the distribution of the world's food output. However, as the globe's 6 billion inhabitants climb to more than 9 billion over the next half century, not only will this mean there are more mouths to feed but there will be less arable land with which to do it. This means that food distribution will have to become more equitable and farming will need to become both more productive and diversified. In addition, to respond to consumer expectations, the quality of plants has to be improved and their nutritional value boosted.

Research Challenge 2: Sustainable agriculture. We urgently need to make today's chemical-intensive agriculture more sustainable while maintaining its productivity. In fact, we need to increase yields and simultaneously reduce or optimise the amount of fuel, fertilisers, pesticides and water used up in the process. The dual challenges of global climate changes and increased seasonal weather instabilities are placing additional strains on the world's agricultural capacity, particularly as more marginal land is farmed.

Research Challenge 3: Green and pleasant land. Agricultural waste can be reduced to a minimum through the efficient use of bio-waste to produce biomaterials and bio-energy. As we run down our supplies of fossil fuels and their environmental impact grows, we will need to substitute them with renewable and environmentally friendly fuel sources. In addition, efficient land management will become increasingly necessary to ensure diversity of agricultural production, protection of the environment and conservation of natural resources and biodiversity.

Research Challenge 4: Competitiveness and consumer choice. A competitive global position for the EU in agriculture, biotechnology and food production will benefit employment and economic growth across the Union. Developing new technologies and agricultural products can help the environment and have a positive impact on rural development. In addition, it would ensure a strong domestic and sustainable European food supply offering consumers a wide choice of healthy and diverse food.

While there was strong support from the respondents (n=101), regarding the importance of all four challenges for plant research in Europe, the strongest support were for sustainable agriculture (99%) and securing a healthy/safe food supply (98%), while green

& pleasant land (88%) and competitiveness/consumer choice (83%) has less support from the respondents.

Examples of the reasons given for lack of support for challenges 3 & 4 were:

- Green and pleasant land is irrelevant to conservation. Competitiveness and consumer choice don't involve conservation bar wider species choice.
- Don't see competitiveness and consumer choice as a major challenge
- It is my strong opinion that we are 'in a state of war' in that this 'state' is the correct mindset to develop a sustainable biofuels industry .... even if this creates changes in the aesthetics as we prefer today (challenge 3) and even if it means we must debate the introduction of 'new' products (bio-energy-products) services because of the markets choice to limit consumer choice because current options are not renewable/sustainable.
- It would not seem to me that producers can target the European Challenges 1, 2, and 3 above and still be competitive. In international competitiveness terms EU producers have their hands tied behind their backs. It appears to me that consumers choose primarily on price regardless of source of origin. 'Health' and 'Green' are nice ideals but price is price for most.
- This is a very limited vision. It understates the ecological role of plants (biodiversity), the role of plants in producing anything from biodiesel to pharmaceuticals, and the role of plants in environmental management (i.e. phytoremedation).
- For both challenges 3 & 4, my impression is that current research capacity can deal with these.
- I refer to the context: "This document "Plants for the Future" sets out a vision for European plant biotechnology and genomics research. The vision was jointly developed by relevant stakeholders, among whom representatives of the biotechnology industry, research, food and seed industries, farmers and consumers." "European companies – such as Bayer, BASF and Syngenta, which are among the world's top six agribusinesses – have committed significant funding to strategic research in crop biotechnology and genomics." These kind of statements set the scene: this is not for the study of semi-natural agricultural systems such as Irish species-rich grasslands.
- Green and pleasant land is a simplistic idea more like a tourist marketing slogan, rather than a topic for research
- Green and pleasant land would appear to me to be more appropriate to environmental science. However, that is not to say plant research is not important in the development of a more visually amenable countryside.
- Competitiveness and consumer choice sound more like economic research goals rather than plant science
- Basic plant research will not significantly affect either a "green and pleasant land" or "competiveness and consumer choice.
- I am not sure Challenge 4 should be a priority issue for research.

- Did not realise that we might want to design plants so that they looked good in the countryside. If this took away from advancing on the other fronts, I would disagree.

Does Ireland have sufficient research capacity in plant research to contribute to addressing the four challenges?

The respondents (n=100) provided their assessment of whether Ireland has sufficient research capacity in plant research to contribute to addressing the challenges (Figure 6). The results to this question were remarkable in that between 35-48% of respondents stated that they did not know. Even though all of the respondents were motivated to respond to a rather lengthy questionnaire on plant research, it is significant that up to half of all plant-research stakeholders in Ireland do not currently know whether Ireland has sufficient research capacity in plant research to meet Ireland (& EU) future needs. Furthermore, of the respondents who did have an opinion, these were almost equally split between those who felt there was sufficient research capacity (27-32%) and those who felt there was not sufficient research capacity (22-33%). Given that food and agriculture constitute <2.5 % of the GDP of Ireland and that plant research is considered critical to future competitiveness of the EU, this lack of current agreement between the key stakeholders across academia, industry and government in Ireland is an issue to be addressed in relation to Ireland's aims to become a knowledge economy.

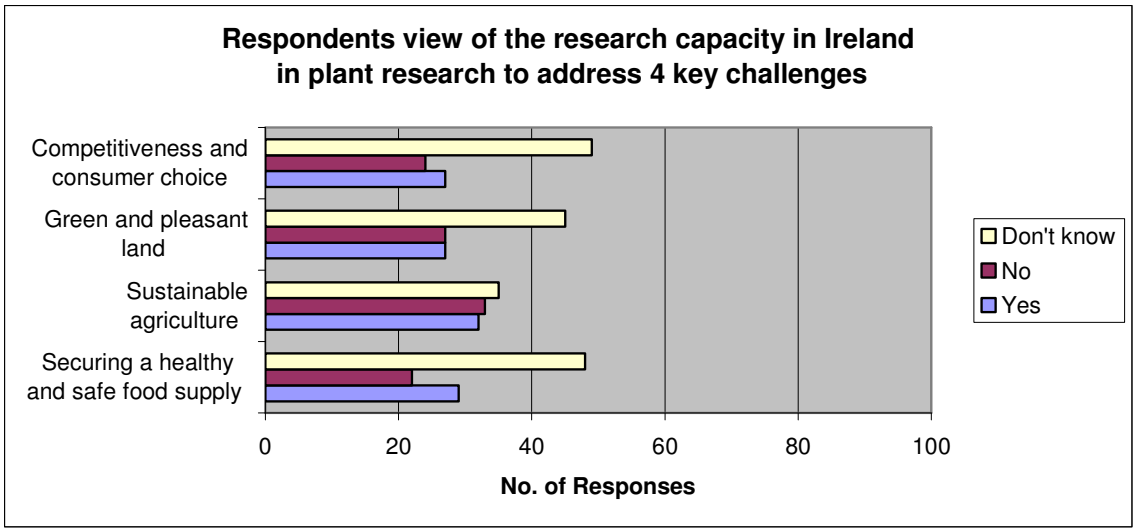


Figure 6: Respondents view of the research capacity in plant research in Ireland to address four key challenges, namely (1) Competitiveness and consumer choice, (2) A green and pleasant land, (3) Sustainable agriculture and (4) Securing a healthy and safe food supply.

We considered that these differences in perspectives could be specific to each of the three main sectors which responded (academia, industry and government). However, it would

seem that within each of these sectors there are significant numbers of don't knows, yes and no respondents (Figure 7). Overall this indicates that there is currently no consensus on whether Ireland has sufficient research capacity for plant research, either across or within the major stakeholder sectors.

Sufficient capacity in Ireland to address :	Academia	Government	Industry
1. Securing healthy & safe food supply	30% Y 23% N 48% DK	30% Y 30% N 40% DK	35% Y 6% N 59% DK
2. Sustainable agriculture	32% Y 30% N 39% DK	45% Y 35% N 20% DK	24% Y 24% N 53% DK
3. Green & pleasant land	25% Y 27% N 48% DK	42%Y 32% N 26% DK	12% Y 18% N 71% DK
4. Competiveness & consumer choice	23% Y 25% N 52% DK	40% Y 25% N 35% DK	24% Y 18% N 59% DK

Table 1: Does Ireland have sufficient research capacity in plant research to contribute to addressing the four challenges. Responses from stakeholders (n=100). Y=yes, N=no, DK = don't know.

The following are examples of the reasons respondents provided as to why Ireland currently does not have sufficient research capacity in plant research:

- Plant research capacity in Ireland is currently very low and fragmented across universities and research institutes such as TEAGASC. Research teams are small and there are no teams of critical mass established which are focussed on Grand Challenges facing Irish society and economy that could be addressed by plant research. Worse still, the historical underfunding of plant R & D in Ireland has led to a situation where the research infrastructure for plant research in the universities is crumbling and in need of major modernisation (e.g. through PRTLI4 and other strategic infrastructure initiatives). So while each of these challenges is directly relevant to Ireland and there are perhaps 30-50 research groups in Ireland that could contribute to these challenges, the lack of strategic funding for improving the quantity, quality and relevance of plant R & D in Ireland has prevented Ireland from developing sufficient research capacity to impact on these challenges.
- Sustainable agriculture / green and pleasant land I suspect that there aren't too many agronomists with a serious interest in the above topics. These topics don't tend to generate revenue or jobs in Ireland so they are down the list of importance.
- For all of the above, basic research and proper interdisciplinary approach are lacking.
- It will be very important to integrate the existing expertise and to establish/promote initiatives that facilitate the development of a 'critical mass' of expertise in key areas.

- As a UK-based scientist I do not have enough specific information about Ireland to answer the question. However, in the UK, notwithstanding a number of excellent research centres, I doubt whether we have the capacity to pursue satisfactorily all these goals.
- Horticultural crop diversification research levels are very low. Plants being used in environment are not refined for Irish landscape. No research and innovation on behalf of the consumer in species and new cultivars exists at a professional commercial level.
- I think that plant research in Ireland has often been a poor relation. Serious funding for plant research has mostly relied on European funding, although SFI has improved things to some extent. Ireland's situation with strong emphasis on agriculture and food demands a greater attention to the needs of plant researchers if the country is to remain at the forefront of European and World agricultural and food production.
- Our science capacity is low in all these sectors.
- We do not debate or seek to be informed therefore we cannot make decisions of any consequence I am unaware if we ever had a desire to be informed and other than your survey I am unaware of any 'decision maker' elected in the Irish-sphere who 'needs to know'.
- Proving sustainability necessitates lots of field based research. The age structure of our existing researchers coupled with a dwindling practical research population mean that we just do not have the critical mass in practical research to answer the necessary questions. Practical producer-based researchers are being killed off by current university employment and promotions policy. We just cannot compete with parts of the world that use efficiency based production practices no longer available here.
- Poorly equipped, isolated research groups not capable of addressing major challenges
- There is insufficient prominence about these issues in Dept of Agriculture (which is still very production-focussed) or Dept of Environment. There is insufficient co-operation between these two Departments, and insufficient research funding.
- Research infrastructure for plant research is generally inadequate but more importantly it is fragmented so that what resources there are, are used very inefficiently.
- There has been a gradual erosion of plant research skills. This is particularly the case in basic underpinning skills such as taxonomy.
- There are at least two issues here - to some extent we do have the potential capacity but this has yet to be realised. The biggest hindrance to this is the lack of investment. Plant sciences in Ireland do exceptionally well given the poor funding opportunities and this prevents individuals/institutions from realising their full potential.
- An overall national plan with regard to challenges in which all research organisations know their role, this would involve the identification and prioritisation of key research areas.

- Green and pleasant land: There are few institutes that are researching this area. The research is aimed at agriculture and to a lesser degree to forestry (mainly evergreen which are not beneficial to the Irish environment on the whole).
- Not enough govt resources or private industry incentives to build a solid strategy
- It all depends on whether Ireland sees these as priority areas and allocates funds to the relevant researchers. Sustainable agriculture for example doesn't sit well with the intensive farming that produces too much nitrates, and is the sector which contributes the most greenhouse gases.
- Sustainable agriculture - Too heavy a reliance on non-competitive subsidies for agricultural outputs instead of relying on good management, diversification into more value added but less volume crops.
- Basically there are not enough researchers to address all of the issues relating to the healthy and safe food supply/sustainable agriculture challenges
- Research has tended to be yield driven and not to focus on consumer satisfaction or sustainability considerations
- We have only minimal plant research capabilities. We need to greatly expand our levels of expertise across all these areas.
- Sustainable: Historically, we have been completely driven by increased production objectives. Most land attached to research institutions that could be used to investigate agriculture on a real scale has been sold.
- Huge environmental concerns related to pollution of Ireland's inland waterways compromise the first three challenges. Much more research is needed to address these issues specifically for Ireland. The last challenge will be market driven and Ireland is falling behind in its competitiveness agenda.
- Clearly, Ireland has not implemented 3% of GNP for research funding and the above areas need to be expanded in Ireland specifically.
- Ireland has a very low capability in plant research in general. Although we have hugely increased our capacity in biotech in general, plant research capability has not increased in proportion. Only 3 of the 80+ biotech fellows appointed by SFI are in plant biotech.
- The GMO question is still unanswered. Feel uneasy regarding the amount of chemicals used on crops, would like to be assured that they are safe.
- There are not so many institutions/working groups in Ireland and therefore often research on a specific topic is carried out by one institution and is therefore heavily biased. Ireland has to extend his capabilities and facilities and work together with other European countries.
- There is very little "industrial-related" plant research (e.g. very few breeding programmes- mostly testing of imported seed varieties). What little research there is tends to be at the basic level which will not really address any of the challenges.
- Capacity in plant research is (and has been) very low in Ireland compared with most other EU countries. Research aimed at sustainable agriculture and securing a healthy and safe food source is minimal and should be increased.
- Competetiveness and consumer choice: In many instances the consumer is not considered.

- Sustainability at and especially above the agricultural level and the concept of a green and pleasant land demands knowledge and research capacity we do not in general possess have, and certainly do not have at 3rd/4th level
- Ireland has a relatively low baseline research in all of the areas mentioned above, particularly in the area of green and pleasant land. There is some research being performed in the areas of safe food supplies, sustainable agriculture and competitiveness and consumer choice. Also, there is very little crossover between the four research challenges identified. For example, research in the area of competitiveness and consumer choice has implications for securing a healthy and safe food supply and for developing sustainable agriculture systems and sustainable agriculture practices must still provide a health and safe food supply.
- I am not sure of the capabilities of research groups in Ireland on the specific platforms
- The plant science capability in Ireland is very small and has been depleted over the last few decades.

What priority are the four challenges for plant research in Ireland & in the European Union?

The stakeholders were asked what priority the four challenges are for plant research in Ireland & the European Union. In general, there was a significant level of concordance between the priorities for Ireland (n= 99) and the European Union (n=100). See Figures 7a & 7b. A disaggregation of the priorities for Ireland and EU based on whether the respondents were in academia, industry or government is provided in Appendix 2.

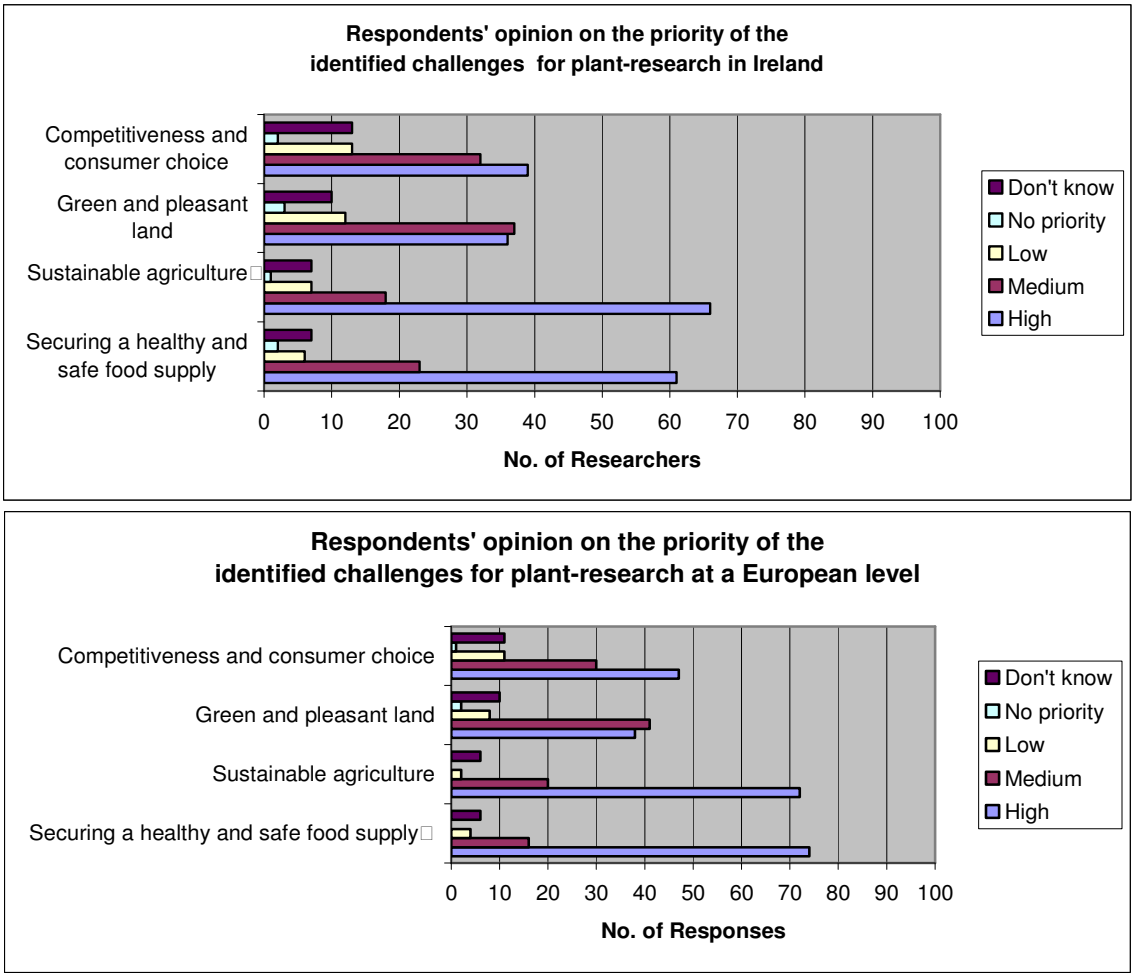


Figure 7: (7a) Responses from stakeholders on what priority are the four challenges for plant research in Ireland (n=99). (7b) Responses from stakeholders on what priority are the four challengers for plant research in Europe.

The stakeholders were also asked whether there were any challenges omitted that should be included for Irish or European plant research. Of the 96 respondents who replied regarding Irish plant research (Figure 8a), 57% indicated that there were challenges omitted, while 52% indicated there were challenges omitted for European plant research (Figure 8b).

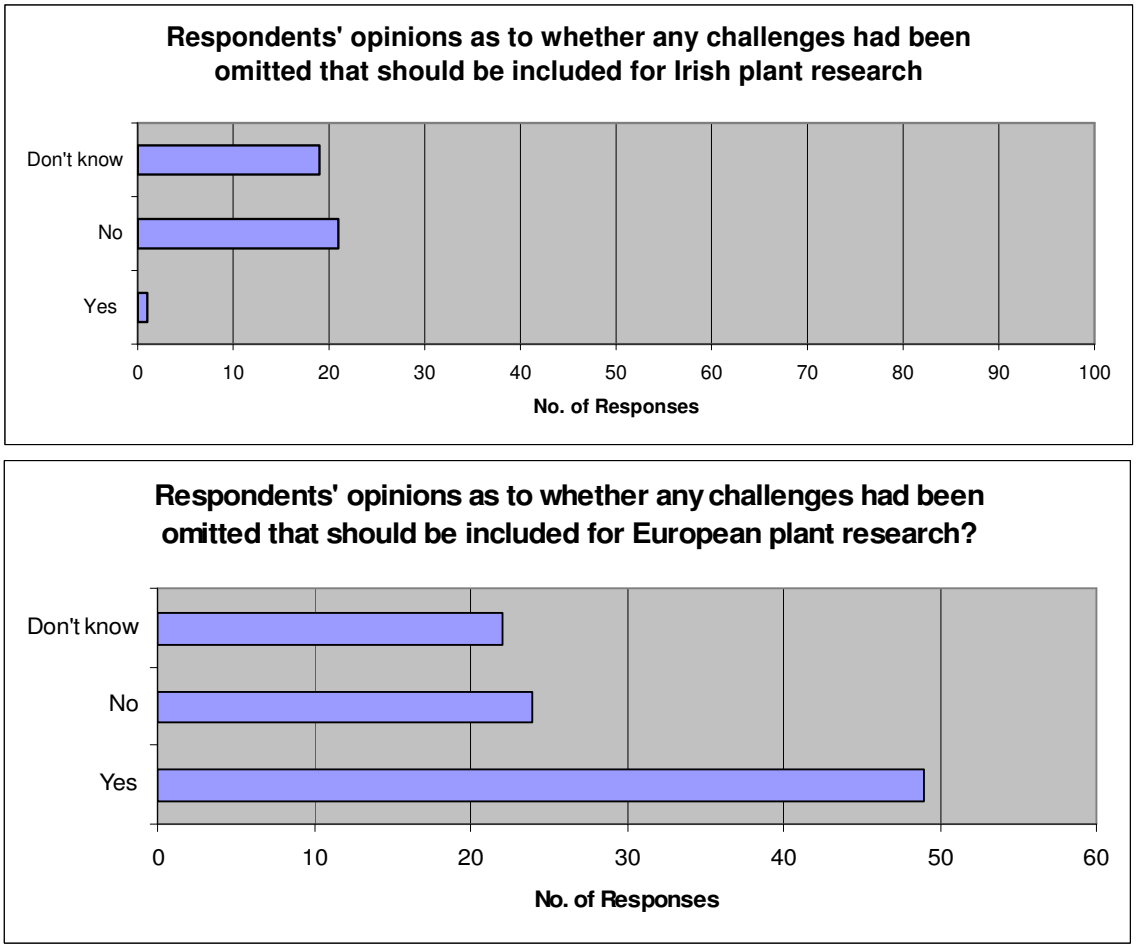


Figure 8: (8a) Responses from stakeholders on whether other challenges had been omitted that should be included for Irish plant research (n=96). (8b) Responses from stakeholders on whether other challenges had been omitted that should be included for European plant research (n=95).

Many of the same challenges for Ireland and the EU were considered by the respondents to have been omitted (Table 2). However, due to the structure of the questionnaire this question may have been difficult for respondents to answer, as many of the challenges considered to be omitted are in fact included in the goals of each of the challenges. In any event, based on the four challenges as presented to the respondents early in the questionnaire, it is clear that bioenergy and novel products are considered important challenges for plant research in both Ireland and EU. Other topics considered important challenges by at least four different respondents were biomedicine, sustainability and conservation, climate change, basic research and biosafety.

	Ireland (n=55)		European Union (n=49)	
Challenges omitted	**No of respondents**	**% of respondents**	**No of respondents**	**% of respondents**
Bioenergy	**12**	**20%**	**11**	**20%**
Novel products	**12**	**20%**	**8**	**20%**
Medicines and pharmaceuticals from plants	**7**	**12%**	**4**	**12%**
Sustainability & Conservation	**8**	**13%**	**14**	**13%**
Climate Change	**5**	**8%**	**2**	**8%**
Basic Research	**4**	**7%**	**3**	**7%**
Biosafety	**4**	**7%**	**5**	**7%**
Quality of products	**3**	**5%**	**1**	**5%**
Public participation & benefit sharing	**2**	**3%**	**2**	**3%**
Ethical research	**1**	**2%**	**1**	**2%**

Table 2: Challenges omitted that should be included for Irish and/or European plant research.

Some of the challenges respondents considered to be omitted for plant research in Ireland were:

- medical plants, herbal, cosmetic, plants as a fuel source
- Having independent energy in Ireland (fuel security)
- Crops for energy supply
- Forestry research
- Development of further value added elements from plants of various sources. Research and development of natural sources of pharmaceuticals, supplements and trace compounds.
- Looking deeper than plants for food use also for nutracueticals
- Development of an agriculture for industrial purposes: plastics, energy, drugs, specific oils.

Some of the challenges respondents considered to be omitted for plant research in Europe were:

- Global medical plant conservation.
- Independent Energy Supply.
- Crops for Energy supply.
- Forestry research.
- Development of an agriculture for industrial purposes: plastics, energy, drugs, specific oils.

Challenge 1: Develop and produce safe and sufficient food & feed

Plants form the basis for almost all life on Earth being the primary source of renewable energy, nutritional ingredients and tissue-building substances for most non-plant organisms, including humans. Crop plants are the basis for our food and feed and in this context there is undoubtedly no other single biological system upon which mankind is as much dependent as crop plants. Improving living standards, particularly in the developed countries, and the growing of the world population from 6 to 9 billion people by 2050 are rapidly boosting global demand for high quality and safe human food and animal feed. The challenge to develop and safe and sufficient food & feed can be met by focussing on three goals:

1. Develop and produce safe and high-quality food

2. Create food products targeted at specific consumer groups and needs

3. Produce safe, high quality, sufficient and sustainable feed

Goal 1.1: Develop and produce safe and high-quality food

Both safety and quality of food is essential and determined by different characteristics. Plant raw material for food and feed need to contain certain main components (carbohydrates, proteins and oils) in desirable amounts, as well as all the factors influencing its nutritional value. Nutrients, such as vitamins, specific classes of unsaturated fatty acids, antioxidants (for example, vitamin E) or mineral nutrients (such as iron or magnesium) are well recognised for having a positive impact on human health. Research activities to achieve goal one will include:

> 5 years: regulatory pathway investigation of compound storage in crops, identification of plant components relating to shelf-life
>
> 10 years: plant quality improvement relating to these key factors
>
> 20 years: creation of crop varieties which satisfy the quality requirements of both consumers and the food industry

Approx 92% of respondents (n=97) agreed that plant research for the development and production of safe and high-quality food was a desirable goal, with 8% indicating that they did not agree with this goal. The priorities of this goal for plant research in Ireland and EU are presented in Appendix 3a & 3b). The 8% who disagreed were distributed across academia (3 respondents), industry (1 respondent) and government (1 respondent). Examples of the reasons for disagreeing with this goal included;

- Optimal nutrition for human health is not achieved by targeting nutritional value of individual plants, but through a diverse and high quality diet and eating experience overall.
- The research activities for the 20year timeframe is "creation of crop varieties...". It is not clear if this means through genetic engineering and release of GMOs into the environment. If GMO release is involved, I do not agree with this goal.
- Given the wide mix of foods in modern diets, it is not necessary to aim for balance in each component.
- Again, the context: with funding from "among the world's top six agribusinesses", I am not sure that I trust ALL research to be fully tested for environmental, wild genome, human and animal safety in the long-term.
- Open to modification of natural foods to attain this goal over all other considerations. Bioavailability of the components not referred to.
- I agree in principle but the way it is worded here is not clear to me. A balanced diet, supplied by many foods, should supply all the required nutrients. It is not sensible to make it a target to achieve this through one plant food. Perhaps I missed the point?
- Is only half of the solution - we have to ensure the foodstuffs we already have are healthy by the removal of contaminants such as fungal mycotoxins, pesticide residues etc.
- Most of these "goals" are simply marketing ploys by the processors to increase market share--- their actual benefits are dubious.

The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=96), and 16% indicated that there were, while 78% did not know. R & D activities underway for this goal in Ireland included:

- Mycotoxin research (F. Doohan, UCD; TEAGASC)
- Novel crop development (P. Jones, UCC); Potato breeding (TEAGASC OakPark)
- Post harvest research (P. McCabe UCD; C Barry-Ryan, DIT)
- Seaweed as animal feed (T. Bennett, Arameara Teo)
- Selenium bio-fortification (C. Spillane, UCC)
- Starch metabolism (Phil Dix, NUIM)

The respondents (n=95) were asked whether there are other plant research priorities for Goal 1.1. at national or European levels. While 66-68% did not know, 11-12% indicated that there were no additional priorities relating to goal1.1 while 20-23% indicated that there were additional priorities for goal 1.1. These included:

- Both levels - diversification of species & nutritional composition of food and agricultural systems. Neo-domestication of crops and other plants of utility to humans.
- The use of native species.
- Natural (or not) resistance to plant diseases.

- Investigate the potential benefits of new nutritional aspects of GM crops.
- Ways of achievement of the goal without GMOs.
- High fibre foods.
- Biotechnology research but needs to be fast tracked.
- Quality (taste) in foods has deteriorated. This needs attention.
- The goal is to achieve this with reduced inputs.
- Understanding of sea vegetable role in overall health. As an island, Ireland has neglected its most bountiful resource.
- Nutraceuticals and functional products.
- Production of safe organic food: we need to know the risks posed by microbiological contamination in this sector and long term effects of organic babyfood with higher levels of natural pesticides.
- Would it be useful to consider nutrient losses which occur in food processing, and then target these in the research program so that these losses can be compensated for by increased levels in the plant? i.e. fortification at source.
- While the nutritional value of existing and novel plant foods must be achieved and labelled, the potential food safety risks must also be avoided and some research priority must be given to assess the food safety of novel plant foods if they are to enter the food chain sustainably.
- Reduce undesirable components of certain foods. Also, research into the relationship between grass composition and milk quality, so as to direct breeding programmes for improved grass varieties.
- There should be research on plants as factories for certain compounds, plants for use in bio-remediation and plants as a source of energy. The latter being the most important.
- Alternative food crops testing for suitability for growing and subsequent food use - development of novel plants, e.g. as cybrids - biofuels - alternative usage of plant raw material, e.g. as substrate for lactic acid production (grasses -extension of research capacities for feed stuff
- Understanding the basis of disease resistance in plants and resistance to abiotic stress
- Europe must not play second fiddle to any other nation or region in biotech.

Goal 1.2: Create (functional) food products targeted at specific consumer groups and needs

Food can do more than meet our basic nutritional need. Some food components can actively supporting our general health and well-being. Good examples of this are plant-derived phytosterols which are added as an ingredient of some margarines. Regular consumption of this kind of margarine reduces blood cholesterol levels which lower the risk of coronary heart disease. For this reason, the Strategic Research Agenda also focuses on developing plant raw materials for healthier/functional foods. Research activities underway for the development of plant-based functional foods include:

Plant raw materials for low-glycemic food, i.e. food containing carbohydrates which are metabolised slowly. This would be beneficial for diabetics.

Plant raw materials for foods enriched with carotenoids – which are found in yellow and orange fruits and vegetables and in dark green, leafy vegetables – and/or polyunsaturated fatty acids. Age-related macular degeneration in the retina of the eye is the leading cause of severe visual impairment and blindness in the elderly. Carotenoids, such as zeaxanthin and lutein, may help prevent this. They can also help lower the risk of heart disease.

Plant raw materials for food with cancer prevention characteristics. There is increasing evidence that certain plant components play a role in reducing the incidence of cancer which is on the rise as our population greys.

Research activities to achieve goal two will include:

> 5 years: identification of the molecular structure of plant polymers, characterisation of anti-cancer plant metabolites
>
> 10 years: identification of strategies causing the accumulation of carotenoids and polyunsaturated fatty acids
>
> 15 years: improve characteristics of crop plants

Approx 93% of respondents (n=94) agreed with this goal, while 7% disagreed. Those who disagreed were from academia (3 respondents) and government (1 respondent). The reasons for disagreement with this goal included:

- Greater consumer choice means LESS targeting of specific groups. Greater information and choice are most important.
- Markets are the movers. Demand creates supply. Marketing is the most expensive method of reversing the above and too expensive.
- All 'foods' should have the appropriate nutritional benefits.
- A well balanced diet has been sufficient for generations, can we not focus on healthy natural foods, which contain these functional ingredients anyway.
- Question is whether this should be publicly or privately funded. I agree with the goal, but feel that as the benefits will accrue largely to private firms, this should be industry-funded research
- Benefits are dubious and if present (marginally) they will be used by producers to increase market share for their product. Diet supplementation would have the same effect on the consumer.

The priorities of this goal for plant research in Ireland and EU are presented in Appendix 4a & 4b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=92), and 13% indicated that there were, while 75% did not know. R & D activities underway for this goal in Ireland included:

- Bioactive plant compounds (R Campbell, Cybercolors)
- Bioactives in seaweed (Cybercolloids)
- Bioavailability of micronutrients (A. Flynn, UCC)
- Biological activities of plant extracts (WF Smyth, University of Ulster)
- Anti-cancer phytochemicals (I Rowland, University of Ulster)
- Phytosterols (N O' Brien, UCC)
- Selenium bio-fortification (C. Spillane, UCC)
- Bioactive plant polysaccharides (M. Tuohy, NUIG)

The respondents (n=95) were asked whether there are other plant research priorities for Goal 1.2. at national or European levels. While 67-72% did not know, 11-12% indicated that there were no additional priorities relating to goal 1.2 while 21-16% indicated that there were additional priorities for goal 1.2. These included:

- Plant research has to be an integral and explicit component of national and EU strategies on functional foods and nutraceuticals.
- At both European and National level - using plants as production systems for high value therapies for humans and livestock.
- Achieving the goal without GMOs.
- There is a need to research the issues which affect teenagers and children's perception of vegetables and fruit and incorporate this research into a body of work presenting the facts about the effects of fruit and veg on their health and well-being in the future. Also the involvement of school children in some level of food research is a possible way to a better understanding of diet generally and thereby increasing consumption of these foods.
- Identification of foods containing high risk toxins and research to identify ways to remove these toxins... perhaps prioritise the targeting of some foods away from high risk groups e.g. pregnant women.
- There is a need for plant research in this area to be undertaken within the wider context of market research on consumer needs. There needs to be a level of consumer awareness in relation to this goal and the R&D ongoing. It is closely connected with market trends and consumer tastes.
- Research activities seem very limited to polymers and anti cancer metabolites plus carotenoids. Many other health promoting activities need to be investigated e.g. effects on cognitive function, gut health, cardiovascular health, diabetes.
- Development of non-land based plant knowledge (e.g. algal biotechnology).
- Alternative processing and novel technologies for plant material.
- The use of by products from processing plants in the development of functional foods should be addressed. The development of such foods will require closer cooperation with industry.
- Bioactive metabolites for other diseases than cancer should also be part of the research priorities in plant research

- Understanding of the vitamin and bioflavonoid, and antioxidant biosynthetic pathways
- The food we have is the outcome of policies designed to "fuel" us not nurture us in an optimal way. It is one cap fits all, does not suppose there may be individual requirements.
- Functional foods.

Challenge 1 Spotlight 1: Functional Foods

Ireland has recently established a National Functional Foods Forum which aims to promote the development of functional foods as a major research and industry sector in Ireland.

Stakeholders were asked whether plant research should be part of an R&D strategy for functional foods in Ireland? Over 90% of respondents (n=93) indicated that they felt that plant research should be part of a national R& D strategy for functional foods in Ireland, and also a part of any European level R& D strategy for functional foods. The remaining 7.5% of respondents stated that they did not know, while ~1% (one respondent) did not think that plant research should be a component of functional foods research in Ireland or Europe. The reason stated was that the initiative seemed more *geared towards product placement in the marketplace* and it was *unclear to the respondent how plant scientists can contribute or will want to contribute to the presentation of plants on a supermarket shelf to the consumer*.

The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=92), and 17.4 % indicated that there were, while 79.3% did not know and 3.3% indicated there were no plant R&D activities underway for this goal in Ireland. R & D activities underway for this goal in Ireland included:

- Bioactive plant compounds – antioxidants & fibres (R Campbell, Cybercolors)
- Bioactives in seaweed (Cybercolloids)
- Bioavailability of micronutrients (A. Flynn, UCC)
- Biological activities of plant extracts (WF Smyth)
- Anti-cancer phytochemicals (I Rowland)
- Phytosterols (N O' Brien, UCC)
- Selenium bio-fortification & metabolic engineering (C. Spillane, UCC)
- Bioactive plant polysaccharides (M. Tuohy, NUIG)
- Post-harvest & food research (Catherine Barry-Ryan, DIT)
- Phyto & diary based functional food technology development (TEAGASC, Moorepark)
- Development of new nutraceutical crop (Peter Jones, UCC)
- Functional and organoleptic properties of cereals (Nutrition, UCC)

The respondents (n=90) were asked whether there are other plant research priorities for functional foods at national or European levels. While 82-78% did not know, 13-12% indicated that there were no additional priorities while 6-10% indicated that there were additional priorities. These included:

- Making plant R&D an integral component of national and EU-wide functional foods research agenda
- Greater emphasis on high-throughput screening of germplasm of minor and underutilised crop/plant species.
- Research on wild and edible fruits/nuts/mushrooms to re-introduce to diets and determine any beneficial physiological or dietary effects of wild plants.
- Investment in core genomic/proteomic/metabolomic platforms for not so well characterised crops
- Development of functional foods that are not subject to GMO regulations
- Development of marker assisted strategies for incorporation of novel traits into plant functional foods
- Building of expertise in metabolic engineering for plant trait enhancement
- Greater understanding of vitamin, bioflavonoid and antioxidant biosynthetic pathways in plants.

Goal 1.3: Produce safe, high quality, sufficient and sustainable feed

Over the past two decades, global meat production has increased rapidly. In the EU and other developed countries, the trend in animal husbandry is moving towards healthier, more convenient and varied meat and dairy products. Industrial feed consumption for livestock production in the EU-15 was largely stable in recent years and is expected to remain constant. The European Union imports some 40 million tons of grain each year – 70% of these protein-rich compounds are used as feed. This situation is unlikely to change without significant plant and crop improvements, particularly for wheat and rapeseed.

In addition to boosting production, safety is likely to remain a crucial issue when it comes to feed. In this context, the reduction of mycotoxins – caused by fungus – in cereals will play a prominent role. According to estimates of the Food and Agriculture Organisation (FAO), the world loses $1 billion (approximately €840 million) worth of foodstuffs due to mycotoxins per year. It is also important to have access to plant raw materials which contain few compounds that negatively influence the growth and health of animals or, in turn, humans.

Another major deliverable under this goal could be quality feed for quality food. The better we understand the feed requirements of cattle, swine and poultry on a molecular level, and the better we adapt feed to them, the higher meat quality will become.

Research activities to achieve goal three will include:

> 5 years: creation of tests to measure mycotoxin presence in plants, assessment of the nutritional qualities required for feed in plant raw material, characterisation of how nutrients build up in plants.

10 years: identification of genes to be used to create novel plants and varieties to support human livelihoods.

15 years: delivery of crop plants to the EU market.

Approx 95% of respondents (n=94) agreed with this goal, while ~5% disagreed. The reasons for disagreement with this goal included:

- Respondent's opposition to use of recombinant DNA technology for generation of novel plants (1 respondent)
- Irish & European research efforts undermined by differing traceability acceptance on cheaper products imported into EU (1 respondent)
- Distrust of research agenda that includes world's top six agribusinesses (1 respondent)
- Opposition to optimisation of quality of meats at molecular structure level – Irish animals should remain pasture fed. (1 respondent)

The priorities of goal 1.3 for plant research in Ireland and EU are presented in Appendix 5a & 5b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=93), and ~26% indicated that there were, while 71% did not know and 3% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Cereal mycotoxin research (Fiona Doohan, UCD; Paul McCabe, UCD; M. Tuohy, NUIG)
- Fungal contamination of silage (Hubert Fuller, UCD)
- Development of new crop varieties (Colin Fleming)
- Plant pathogen resistance breeding & research (Dr. Dardis; Max Dow, UCC; Tony Kavanagh, TCD)
- Development of seaweeds as animal feeds (Arameara Teo)
- Biodegradation and plants (Alan Dobson, UCC)
- Animal feeds & supplements R & D (Alltech)
- Selenium biofortification of crops (Charles Spillane, UCC)
- Research by Prof Mike Cooke (UCD); Jimmy Burke (TEAGASC, OakPark)

The respondents (n=95) were asked whether there are other plant research priorities for Goal 1.3. at national or European levels. While 77-75% did not know, 9-9% indicated that there were no additional priorities relating to goal 1.3 while 14-16% indicated that there were additional priorities for goal 1.3. These included:

- Relationship between meat quality and plant nutritional profiles
- Distinguishing and choosing between two options (GM & non-GM crops)
- Lowered allergen content for food crops

- Determining whether feed production is sustainable within EU/Ireland as lack of producer returns is the major threat in medium term
- Factoring consumer concerns re food safety into R&D
- Exploring European possibilities for protein production (soya and other crops)
- Genomics efforts towards improved feed quality
- Animal food uptake studies for improved feedstuff
- Secondary effects of animal feed on human nutrition and health

Challenge 1 Spotlight 2: Plant research for healthier foods and diets

The respondents (n=94) were asked should plant research be used to develop healthier foods and diets. 92.6% of respondents indicated that plant research should be use to develop healthier food and diets, while 4.3% indicated did not know. 3.2% (4 respondents) felt that plant research should not be used to develop healthier food and diets for the following reasons:

- It is people's responsibility to choose to eat the right things and plants are healthy as they are. The development of healthier plants is a fad. (1 respondent)
- Distrust of research agenda that includes world's top six agribusinesses (1 respondent)
- Plants should be used in diets as whole foods without any extraction or processing (1 respondent)

The respondents (n=94) were asked whether Ireland should play a role in plant research to develop healthier foods and diets. 92.5% of respondents indicated that Ireland should play a role, while 2.1% did not know. 5.4% (5 respondents) indicated that Ireland should not play a role in plant research for this objective for the following reasons:

- Such research is total contrivance (1 respondent)
- Distrust of research agenda that includes world's top six agribusinesses (1 respondent)
- Beneficial effects of whole foods may be greater than any bioactive compounds in isolation (1 respondent)
- If the research is funded by industry (1 respondent)

The respondents (n=93) were asked which of the following options should be undertaken to meet increasing food demands; (a) doubling the area of arable land, (b) doubling crop productivity, (c) both and (d) other. The responses to this question are shown in Figure 9.

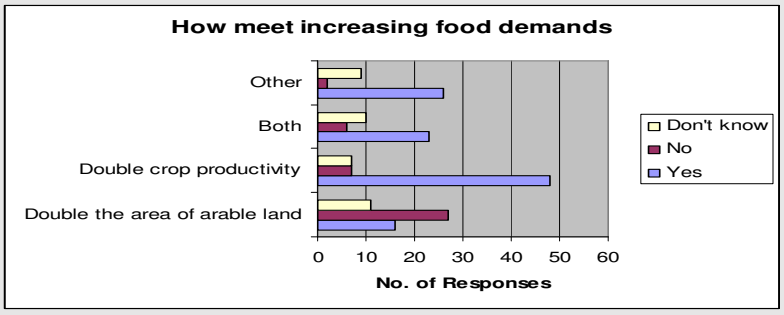


Figure 9: Respondents (n=93) views on options for meeting increasing food demands.

The following were the other options that respondents indicated for meeting increasing food demands:

- Promote vegetarianism among adult populations – reduce dependence on animal foods & increase dependence on plant foods
- Outsource food production to countries where food production is more efficient
- Remove the CAP and other barriers to free trade in food and food products
- Introduce a food-miles tax to reduce energy loss in food transport
- Incentivise development of locally adapted foods which are in season
- Promote collaboration between researchers, crop producers and national organisations to diversify agricultural product outputs
- Reducing waste in the consumption chain
- Develop business & research partnerships with third countries in order to ensure high quality sourcing rather than sourcing on world markets
- Post-harvest studies including distribution technologies
- Investigation of intercropping and crop mixtures
- In Ireland, focus on developing high quality domestic animals on semi-natural grasslands
- Improved storage, preservation and processing technologies
- Continuing crop improvement through breeding and biotechnology
- Used waste products more efficiently
- Organic farming
- Develop crops which can grow in marginal conditions and which are less environmentally damaging (water efficiency etc)
- Support small-scale local tillage

Challenge two: Sustainable agriculture, forestry and landscape

Today, around 800 million people (13% of the world's population) are malnourished. However, the unprecedented food abundance in many parts of the industrialised world makes many people, including Europeans, oblivious to the want elsewhere. Over the next 20 years (2005 to 2025), the challenge is not only to satisfy growing demand but also to do it in a sustainable manner.

This Technology Platform will result in new knowledge of plants that can help to address future needs. Examples will include new energy-efficient farming practices and how the use of fertilisers and of phyto-chemical products can be modified. It will also help broaden the range of European crops, satisfy emerging needs for energy and renewable raw materials, and reduce energy-consuming transportation of food. The research challenge will be to develop sustainable agriculture, forestry and landscapes.

This sustainability challenge will focus on four goals:

1. Improve plant productivity and quality
2. Reduce and optimise the environmental impact of agriculture
3. Boost biodiversity
4. Enhance the aesthetical value and sustainability of the landscape

Goal 2.1: Improve plant productivity and quality

We need to strike a sound balance between boosting productivity and providing consumers with the products and quality they require. Part of the answer lies in plant genomics – understanding how all the inherited characteristics of a plant combine to imbue it with its intrinsic characteristics. The factors that influence yield, for instance, should be important in supplying a growing world population with affordable and safe food of adequate quality and quantity. Understanding how plants can produce the renewable fuels and raw materials that industry and consumers need would help lower dependence on fossil fuels and native forests. Plant genomics can also help manage natural resources and biodiversity optimally.

Deliverables and research activities include:

> Five years: For each crop, including cereals, legumes, oil and fruit-producing species, as well as for tree species, the bottlenecks limiting productivity and affecting the stability of yields need to be identified using physiological and molecular approaches. Factors contributing to the quality of harvested products, including deleterious ones, should be identified.

Ten to twenty-five years: On this basis, molecular breeding tools can be used to obtain elite cultivars cumulating in a high photosynthetic capacity, an optimised growth cycle and architecture, an improved tolerance to abiotic factors with emphasis on water-use efficiency and adaptation to low temperatures. Cultivars displaying stable yields under varying environmental conditions should also be obtained. Finally, new varieties with high quality and good taste can be obtained for major crops used as food sources.

Almost 99% of respondents (n=91) agreed with this goal, with 1 respondent disagreeing because they felt that the improvement of plant productivity may lead to a rise in GM foods or adding unnatural substances to food.

The priorities of goal 2.1 for plant research in Ireland and EU are presented in Appendix 6a & 6b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=91), and ~34.1% indicated that there were, while 63.7% did not know and 2.2% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Genetics/epigenetics of seed traits (Charles Spillane, UCC)
- Plant breeding of new cultivars – potato, white clover, perennial ryegrass (Teagasc Oakpark)
- Selection of better cultivars (Crop Variety Testing Div, Dept of Agriculture, Co. Kildare).
- Use of SRC willow, miscanthus (AR McCracken, Dept of Ag and Rural Development, Northern Ireland)
- Carbon sequestration research in tillage and forestry (Mike Jones & Bruce Osborne, TCD)
- Development of novel N-fixing crops (Bruce Osborne, UCD)
- Drought tolerant wheat (Pete Jones, UCC)
- Novel crops development (Pete Jones, UCC)
- Crop research (Applied Plant Science, DARDNI, Belfast, Northern Ireland)
- Miscanthus for biofuels/bioenergy (Mike Jones, TCD)
- Hardwood tree improvement (TEAGASC, Kinsealy)
- It was stated that all conventional plant breeding activities in Ireland were at a very low intensity and state of support. Current research is mainly at the level of plant variety breeding and is non-molecular in nature

The respondents (n=91) were asked whether there are other plant research priorities for Goal 2.1. at national or European levels. While 68-70% did not know, 14-10% indicated that there were no additional priorities relating to goal 1.2 while 18-20% indicated that there were additional priorities for goal 2.1. These included:

- not focussing on yield per se but on high-yield stability and high-yield ability under more environmentally friendly farming practices (IPM, INM, no till)
- non-GM approaches to achieving goal
- Landscape plant suitability for food chain diversification and awareness.

- maintenance of agricultural productivity despite reduced inputs
- development of novel crop plants and/or cropping systems.
- understanding the mechanism(s) by which plants respond to environmental cues.
- Nutrient utilisation, nitrogen utilisation, water utilisation
- Use of plants for biofuel and bioenergy
- Use of wetlands as biofilters

Goal 2.2: Reduce and optimise the environmental impact of agriculture

A second sustainability priority is to reduce the environmental impact of agriculture. Developing milder crop protection methods will probably require both improvements in the management of phyto-chemical products and the development of self-protected plant varieties. Research can identify genes involved, for instance, in pest tolerance/resistance and this would allow plant breeders to select for such traits.

Water is likely to become scarcer. While better irrigation management is essential, plant genomics can also help design 'water-efficient plants' by identifying sets of drought tolerant genes which are suitable for various climatic situations. Optimising fertilisation is a related challenge. Plant genomics can improve the efficiency of nitrogen use in crops by characterising the relevant metabolic pathways and identifying the relevant genes.

Europe is the cradle of plant breeding and plant biotechnology, and has the potential to meet these challenges and create more sustainable cropping systems by combining genomic approaches with analytical techniques, molecular breeding and biodiversity studies.

Research activities to achieve goal two will include:

> 5 years: development of monitoring tools that determine when and where to deliver agrochemicals and also trail the cycle of the delivered molecule to help optimise practices, development of tools for the early diagnosis of disease or pests, creation of new crop management practice to prevent nutrient leakage
>
> 10 years: identification of pest/disease resistance in plants to minimise the need for agrochemical additions
>
> 15 years: delivery of crop plants to the EU market

Over 86% of respondents (n=89) agreed with goal 2.2, with 13.5% disagreeing with the goal for the following reasons:

- Use of genetic modification (GMO outputs) as approach (7 respondents)

- Lack of/few commercial applications of these traits except for BT maize (1 respondent)

The priorities of goal 2.2 for plant research in Ireland and EU are presented in Appendix 7a & 7b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=89), and 25.8% indicated that there were, while 70.8% did not know and 3.4% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Pest and pathogen resistance in plants (Max Dow, UCC)
- Traditional research underway in agricultural plant research labs (Universities and in Teagasc)
- Development of natural 'pesticides/herbicides' and novel bioactive horticultural additives/plant growth stimulators from plants of marine and terrestrial origin, fungi and crustaceans (Dr. M. Tuohy, NUI, Galway in collaboration with OGT)
- Plant breeding (Ed Walsh, UCD; Jim Burke, Teagasc Oakpark Carlow)
- Development of low chemical disease control (Northern Ireland Horticulture & Plant Breeding Institute, Loughgall, NI)
- Plant research (Applied Plant Science, DARDNI Newforge Lane Belfast)
- tillage treatments (Mike Jones, Trinity College Dublin; Catherine Coxon, Trinity College Dublin; Michael Williams, Trinity College Dublin)
- development of molecular markers against a potato nematode (Dan Milbourne, Teagasc)
- Testing agrochemical efficacy on crops at Teagasc
- Plant-pathogen molecular genetics research (Tony Kavanagh, TCD).
- Biopesticides for plant disease control (Fiona Doohan, UCD)
- It was commented that this goal would seem better suited to international research which would be ahead of current Irish expertise.

The respondents (n=88) were asked whether there are other plant research priorities for Goal 2.2 at national or European levels. While 68-67% did not know, 13-10%% indicated that there were no additional priorities relating to goal 2.2 while 20-23% indicated that there were additional priorities for goal 2.2. These included:

- Both national and EU levels, including a GM approach to generate pest/disease/drought resistance
- Using evolutionary biology to inform applied plant research
- Finding non-GM approaches of achieving the goal
- Need to consider crops we grow from the point of view of value they deliver versus the impact of inputs
- Recombinant genetic approaches can be used on the same lines as traditional techniques to increase yields and generate plants that can survive and be productive in extreme growing conditions.
- Pursue research and use of GM crops to achieve this goal

- Need much more functional genomics to address these issues, combining molecular/physiological and biochemical approaches.
- dealing with the waste products of intensive agriculture (e.g. use of arable waste for biofuels, use of animal by-products as fertiliser, biofuels. At least safe disposal protocols
- Crop management and reducing greenhouse gases (notably N2O from agric sector)
- extension of work on resistance genes and molecular markers for screening of resistance/susceptibility genes.
- if you are going to use gm crops to help achieve above goals then public needs to be reassured it is safe.

Goal 2.3: Boost biodiversity

The third sustainability priority should be to enhance and utilise plant biodiversity. Firstly, we need to characterise and maintain the biodiversity that exists in the field. We already have the tools to evaluate how different farming practices affect biodiversity (ecological surveying, modelling, etc.). These can generate knowledge which would allow better biodiversity and landscape management in rural and suburban areas.

Part of our existing biodiversity lies in the collections of plant varieties and related species in gene banks. These have served as the sources for many crop improvements. However, hundreds or thousands of stored seeds with potentially useful properties have never been explored. We now have the tools to look for the genetic biodiversity hidden in those collections.

The domestication of new plant varieties would greatly increase biodiversity within agriculture. The majority of crops grown in Europe originate from domestication processes that occurred thousands of years ago in specific areas, such as the Fertile Crescent (for wheat and barley). Crop improvement introduces diversity by bringing in the genes for specific traits from wild relatives of crop species. But with a greater understanding of a wider range of plants, breeders may also be able to bring wholly new crops to farmers. We may be entering a new phase in which the management of biodiversity in agriculture can lead to the development of crops more closely adapted to our needs.

Research activities to achieve goal three will include:

> 5 years: comparison of the impact of different practices on biodiversity, collection of diverse samples of major crops, identification of wild species of plants of interest, study of the biodiversity of tree populations
>
> 10 years: study of the biodiversity of pathogens and pests
>
> 25 years: transformation of wild species into new crops

Almost 88% of respondents (n=91) agreed with goal 2.3, with 12.1% disagreeing with the goal for the following reasons:

- Breeders and environmentalists talk about achieving 'greater biodiversity' without considering the consequences. Humans have made an impact on the environment through agriculture - we cannot pretend producing more species will make it better. Too unpredictable. Might make it worse.
- Only agree if goal is achieved by natural methods
- Farming by its very nature must impact on biodiversity and we will continue to want food. Every time we try to manipulate biodiversity to our advantage using genes or whatever tool we are automatically impacting on it somewhere else. Nature has created the biodiversity we have today and it will continue to do so. Which is better -- to force a little extra diversity into a section of land or to give a small portion of land back to nature so that it can operate a full ecosystem with all its own natural and evolving biodiversity.
- There are valid concerns that plant research and breeding could actually reduce biodiversity with new varieties which have been bred to be particularly resilient actually supplanting previous varieties. Need to be careful about preserving biodiversity. There are concerns in relation to the appropriation of intellectual property rights over wild species by private enterprise.
- Maintain biodiversity rather than boost. Also, there is a real conflict between the drive for efficiency and diversity within a production system. Diversity and uniformity can both be pursued - side by side
- This only addresses biodiversity as created by biotech. The wider context of wild gene biodiversity, let alone wild species or habitat biodiversity, such as laid out in the Convention for Biodiversity, is not addressed.
- Danger of introducing new species with higher fitness than the endogenous ones
- There is very little good evidence that crop improvement boosts biodiversity

The priorities of goal 2.3 for plant research in Ireland and EU are presented in Appendix 8a & 8b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=90), and 27.8% indicated that there were, while 70% did not know and 2.2% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Genetic diversity/variation screening in plant/crop genepools, including underutilised and new crops (Charles Spillane, UCC).
- Exploration of different wildflora crops ~ 168 species to develop novel uses (Sandro Cafollo, All GoWild)
- Plant research at NUI, Galway (Dr. M. Tuohy) and colleagues in Teagasc & COFORD
- Impact of invasive species on biodiversity (Margherita Gioria, UCD)
- Research on native plant biodiversity for nature conservation purposes e.g. site designation and as part of the Irish Biodiversity action plan and NI Biodiversity Strategy e.g. looking at the genetics of plant species (including trees) and surveys of poorly known taxonomic groups such as bryophytes and lichens.

- Burren LIFE Project (Brendan Dunford) Burren habitat mapping (Grace O'Donovan, Sharon Parr, John Finn. Johnstown Castle, Teagasc.
- BIOFOREST, EPA-funded biodiversity project. (John O Halloran, Paul Giller, Tom Gittings, UCC)
- Agbiota project (Gordon Purvis, UCD)
- Some small initiatives for biomass crops, for instance, but little on a farm scale.
- Bioforest research group investigating biodiversity in natural and commercial plantations (Dr Daniel Kelly , TCD)
- Screening diversity in perennial ryegrass and white clover (TEAGASC OakPark)
- Conservation of heritage varieties e.g. apples (Irish Seed Savers Association)
- Researchers in all of the universities and TEAGASC but all activity at a low level by too few researchers.
- The introduction of genes from wild species has traditionally served as a means of introducing variation into the gene pool. Cultivated varieties of a particular species can become very narrow. A good deal of research has been conducted into the crossing of wild relatives with commercial varieties with some degree of success. However, Ireland does not have the expertise in this field, nor the dedicated breeding research therefore, this goal would appear important for plant research in Europe but not so much for Ireland

The respondents (n=87) were asked whether there are other plant research priorities for Goal 2.3 at national or European levels. While 75-75% did not know, 9-8%% indicated that there were no additional priorities relating to goal 2.3 while 16-17% indicated that there were additional priorities for goal 2.3. These included:

- Plant biodiversity should also be co-assessed for chemical diversity to achieve high productivity.
- functional diversification of the intra-species and inter-species plant composition of food and agricultural systems.
- Domestication of new crops from wild species.
- Re-domestication of existing crops to develop completely new ideotypes.
- Understanding molecular and genetic networks that contribute to plant diversity Evolution of plant diversity
- Impact of invasive species on native species and ecosystems
- Preservation and enhancement of naturally-occurring biodiversity.
- Analysis of loss of native natural fruiting species from hedgerows and wild areas & . bring back into production some of these species and local clone examination.
- This goal emphasises agricultural genetic biodiversity, and genetic manipulation techniques as the priority for 'boosting biodiversity'. However, a priority for 'boosting biodiversity' is to understand and mitigate the habitat impacts of agronomic practices and to protect existing natural habitats.
- Along with the technical R&D activities there also needs to be research on the area of intellectual property and the development of appropriate legislation and protection to prevent the appropriation intellectual property rights over wild species by private companies.

- Continued discovery and incorporation of variation into the plant gene pool.
- Development of cybrids of cultivated and wild relative species
- Extension of molecular breeding programmes (e.g. use of molecular markers in backcross breeding)
- Development of enhanced mapping methods to follow up introgression of wild relatives genes into cultivated material
- **T**his view of biodiversity is extraordinarily narrow, and if focussed on what Europe or Ireland currently holds will in the end prove inadequate.

Goal 2.4: Enhance the aesthetical value and sustainability of the landscape

Land should no longer be viewed solely as a production silo, but rather as complex interconnecting networks and reservoirs of natural resources, which can be used for human benefit without long-term damage to the biodiversity that underpins all systems.

Deliverables and research activities include:

> Five years: Ornamental plants are an important component of our everyday landscape. Their tremendous diversity needs to be preserved. An inventory of genetic diversity of ornamental plants should be performed, taking into account their regional specificities.
>
> Ten years: Their invasiveness in the environment and possible genetic exchanges with related wild species should be assessed.
>
> Twenty-five years: Improved management strategies can be built on these observations to preserve natural biodiversity of local crops as well as wild species, and to contribute to sustainability issues, such as recycling strategies, energy production, and fire prevention.

Over 92% of respondents (n=89) agreed with goal 2.4 with 7.9% disagreeing with the goal for the following reasons:

- All agriculture changes the landscape and much of what is regarded as countryside is actually farmland. Further, the preservation of biodiversity is a worthy goal but actually if it was pursued to logical conclusions we would not have fields of crops - rather we would have wild habitats. In the end, all crop production must exclude a lot of biodiversity just to allow the crop to grow.
- If you view land as being multifunctional it becomes unreasonable to demand that producers be able to internationally compete with others who pay no heed to the environmental component of land.
- We have always viewed the land as complex interconnecting networks and reservoirs of natural resources.

- Depends on whether you are a middle class urbanite with grand notions of their own existence and importance or the average farmer or other worker striving to make a living.
- Don't believe that land is viewed as a production silo by the vast majority of producers. I accept that there is a requirement to protect the aesthetical value and sustainability if the landscape, this has been done to a large degree by REPS. Recent work by UCD and QUB has sought to quantify the public's willingness to spend their taxes in this area.
- Not so clear that plant R&D has a major role in ensuring that this becomes a widely-held perception.
- Needs to have more emphasis on human benefit.

The priorities of goal 2.4 for plant research in Ireland and EU are presented in Appendix 9a & 9b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=88), and 25% indicated that there were, while 78.4% did not know and 2.3% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Fitzgerald Nurseries have set up an R&D facility to explore new ornamental crops. and currently have an active research program on ornamental plants. Fitzgerald Nurseries have had collaborations with UCC and UCD in the past, and currently have a project with Teagasc on a phyto-cleaning program for ornamental plants. Fitzgerald Nurseries are currently working on a Bord Bia funded project developing propagation systems for 20 plants of commercial merit for export and home market sales in conjunction with other Irish nurseries. Website: http://www.fitzgerald-nurseries.com/Trials_Field.htm
- Use of native wild flowers for landscaping purposes (AllGoWild, Carlow)
- A report on the impact on invasive species on native biodiversity was produced by Quercus for National Parks and Wildlife Service.
- Establishment of the best management practices for habitat conservation in upland grasslands and heathlands in Connemara, species-rich grasslands in the Burren and on midland eskers and turlough grassland and fen vegetation. This has always been in the context of current and future farming practices in the area (NUIG, Galway)

It was commented that the biodiversity aspects of this research area could be integrated with ongoing research in Ireland promoted under Ireland's Biodiversity Knowledge Programme and also ecosystems oriented research funded by TEAGASC, EPA and others in Ireland.

The respondents (n=86) were asked whether there are other plant research priorities for Goal 2.4 at national or European levels. While 72-74% did not know, 10-9%% indicated that there were no additional priorities relating to goal 2.4 while 17-16% indicated that there were additional priorities for goal 2.4. These included:

- New crop introductions & understanding what genetic factors are responsible for traits such as invasiveness and weediness.

- Measurement of the invasiveness and genetic exchange of GM crop varieties/species (GM & non-GM) with wild relatives
- Policy for introduced species
- Sustainable Landscape management requires multi-disciplinary research, such research must be given high priority, as it would minimise the risk of the mistakes that occur due to 'blinkered' vision.
- Integration of social and environmental criteria with economic. Unclear why proposed focus is on ornamental plants.
- It was commented that this goal is more of a more landscape management planning than plant biotechnology challenge. It was stated that if this truly is the objective, then the aesthetical value and sustainability of the landscape will not be best supported by the above research activities. Priorities should then be descriptions and active management of existing, desirable landscape features, and research into how diversity assists the provision of ecosystem services. It was also stated that the focus should not be so narrowly on ornamental plants and could be broadened to include wild species and ecotypes.

Challenge three: Green products

Today, fossil reserves drive the success of the global economy. In Europe, more than 90% of economic activity arises from technologies dependent on coal, gas and oil. Oil is both the source of transport fuels and of the petrochemicals used by manufacturing industries to make the products that underpin our consumer society – from plastics to pharmaceuticals and construction materials.

The problem facing our world is that fossil resources are finite: they are likely to be exhausted by a global society that is growing in size and becoming increasingly industrialised. Already, oil prices have reached €70 per barrel. As oil supplies further decrease, security as well as cost becomes an issue, and a worldwide chemical industry dependent on petrochemical feedstocks must seek alternative sustainable supply chains. This is not a choice, but a requirement – the only question is timing. The world already recognises that the problem is urgent, both from the perspective of fossil fuel reserves and the negative environmental impact that an oil-driven economy is wreaking.

Part of the solution can be provided by tapping into the raw materials provided by green plants. Plants use solar energy, water and carbon dioxide to manufacture simple sugars that are converted in the pathways of primary and secondary metabolism into a vast array of complex chemicals: carbohydrates, oils, proteins, and other products. Plants can provide cost-effective biorenewable feedstocks for sustainable supply chains – fuelled by the sun and dependent only on the manufacturing capacity of the living cells that make up the 'plant factory'. These supply chains would feed the global chemicals industries, but also include pharmaceutical manufacturers. A clear vision is urgently required for the research and development activities necessary to maximise the utility of these bio-renewable resources. This is particularly relevant given that the EU aims to extract 20% of the raw materials for transport energy from plants.

This challenge focuses on two main goals:

1. Plants as a basis for renewable resources
2. Plant-based pharmaceutical and diagnostic products

Main Goal 3.1: Plants as a basis for renewable resources

Goal 3.1.1. Improving the efficiency of existing industrial crops and the utility of their products.

Plants are already cheap renewable factories for the production of many raw materials and chemicals of considerable value to a wide range of non-food sectors. These existing crops and their products can be improved. This improvement relates to the quantity and quality of the raw materials, as well as the post-harvest use of those materials in the

supply chains of the different industrial sectors. Improvements can arise from basic agronomy and improved field and forest cultivation methods, breeding to improve yield and robustness in quality of products made, and improved post-harvest technologies that affect extraction, separation and processing to increase the utility of the raw materials that the plants have manufactured.

Fast-track breeding should be informed by post-genomic technologies and the increasing insights that can be gained from systems biology. For immediate European uptake and field cultivation of improved industrial crops, technologies that do not use genetic modification (GM), such as tilling, can be developed. The enabling technologies of bioinformatics, gene discovery and gene function assays that underpin tilling, also provide the knowledgebase for future GM-based crop improvement strategies.

Research activities to achieve goal 1.1 will include:

- an increase in the robustness of supply chain
- analysis of the environmental impacts and the lifecycle of raw materials generated
- study of the links between environmental conditions and plant adaptation to those conditions in order to standardise the yield and quality of raw materials
- understanding of disease resistance and nutrient use at molecular level

Almost 99% of respondents (n=88) agreed with goal 3.1.1 with ~1% (one respondent) disagreeing with the goal because they felt the following "If choice between increasing quality of foods by artificial or genetic means or to concentrate on great consumer choice, would opt for the latter. Better trade with EU and fair trade/ more resources for developing countries a greater priority."

The relative priorities of goal 3.1.1 for plant research in Ireland and EU are presented in Appendix 10a & 10b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=88), and 23.8% indicated that there were, while 70.5% did not know and 5.7% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Molecular pharming (production of pharmaceuticals in plants) research (Tony Kavanagh, TCD; Phil Dix, NUIM; Charles Spillane, UCC; Marcel Jansen, UCC).
- Natural products extraction from plants e.g. biopharma products/natural biopolymers and oligomers/phenolic substances/flavonoid glycosides from plants (M. Tuohy, NUIG, Galway).
- Plant genomics & biotechnology research on micronutrients, reproduction and pharming (Charles Spillane, UCC)
- Biomass & bioenergy crops (Bernard Rice, TEAGASC; Mike Jones, TCD)
- Understanding of disease resistance at the molecular level (Tony Kavanagh, TCD; Max Dow, UCC; Fergal O'Gara, UCC)
- Dairy functional foods research is based on plant-derived bioactive compounds (TEAGASC, Moorepark; UCC)

It was commented that there was not a great fit between the goal and the research activities planned. It was queried why disease resistance should be particularly related to this goal, when it is equally relevant to other goals.

The respondents (n=85) were asked whether there are other plant research priorities for Goal 3.1.1 at national or European levels. While 78-77% did not know, 12-13%% indicated that there were no additional priorities relating to goal 3.1.1 while 10-10% indicated that there were additional priorities for goal 3.1.1. These included:

- Non GM-based approaches to achieving the goal
- Oil and ethanol production from crop plants
- Research must be linked with research into the efficiency and effectiveness of conversion technologies to generate energy from the crops.
- Research on seaweeds
- Understanding the effects of abiotic stress at the molecular level.
- Identification of other value-added products from waste plant material

Goal 3.1.2 Expanding the quality of raw materials and product range of industrial crops – new plant-based raw materials with widened utility:

By gaining a greater understanding of how plants function, particularly in terms of their development, metabolism and the impact of the environment on these processes, new opportunities for altering the range of products plants manufacture are likely to emerge. Considerable advances can be made through classical plant breeding and the use of fast-track breeding methods, such as tilling. Changes in the level of expression of different genes can help alter the yields and patterns of metabolites made by the plants.

It is an aim of systems biology to understand the plant from a holistic standpoint and develop predictive models for bringing about specific changes. These research advances will be instrumental to the utility of plant-based biorenewables in years to come. Products can be designed that more closely align to the needs of supply chains and end-uses. The plant can also be modified to improve the raw materials for post-harvest processing, such as the biorefining.

Significantly, the biosphere has already evolved solutions to many industrial problems and gene discovery programmes should identify new opportunities for increasing the product range of plants through the use of genes from other organisms to modify the plants' metabolism or to manufacture entirely novel products.

In contrast to the former applications, these will rely on GM technology. Within Europe, immediate uptake can occur if industrial GM plants are cultivated in strict containment, such as needed for pharmaceutical production. Elsewhere in the world, GM applications

for industrial crops are already improving many post-harvest processes, as well as leading to the manufacture of novel biopolymers, fibres and biomaterials.

Research activities to achieve goal 3.1.2 will include:

- uncovering of novel functions in existing raw materials
- alteration of existing compounds as replacements for fossil fuels
- exploration of biodiversity for the creation of new products e.g. design of new fibre based materials

Over 96% of respondents (n=88) agreed with goal 3.1.2 with 3.4% disagreeing with the goal for the following reasons:

- Goal seems to have a GM crop focus
- Not enough information provided
- Goal is too vague – would be better to focus on niche areas like biofuels.

The relative priorities of goal 3.1.2 for plant research in Ireland and EU are presented in Appendix 11a & 11b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=88), and 18.4% indicated that there were, while 75.9% did not know and 5.7% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Genomics & epigenetics of seed traits (Charles Spillane, UCC)
- Novel functions of existing materials, bioethanol/biofuel production from cereals and other agricultural crops, woody materials (including residues and papers) and from VFCW/OFMSWs (i.e. plant-rich wastes). (M. tuohy, NUIG, Galway)
- Enhanced production of secondary metabolites through tissue culture methods for therapeutic qualities (germain Leveille & Graham Wilson, UCD)
- Extraction and characterisation of plant-derived bioactives (Cybercolloids)
- Extraction and characterisation of seaweed-derived bioactives (NUIG, Galway)

The respondents (n=87) were asked whether there are other plant research priorities for Goal 3.1.2 at national or European levels. While 74-76% did not know, 15-13%% indicated that there were no additional priorities relating to goal 3.1.2 while 10-12% indicated that there were additional priorities for goal 3.1.2. These included:

- Exploration of potential of wild and underutilised species for potential to contribute energy or novel compounds
- development of more effective utilisation of existing known products
- Greater and novel roles plants may have in building industry e.g. as insulation

Challenge 3 Spotlight: Biofuels

Like most other economies, Ireland is heavily dependent on fossil fuels, such as coal and oil for transport, energy and heating. There is an ongoing need to diversify the energy sources supporting Irish economic development, ideally through the development of renewable energy sources such as wind, wave, hydro and bioenergy.

There are a number of reasons why plant-based bioenergy systems should be developed in Ireland.

These include:

1. Energy supply security - reduction of our dependence on imported energy through the development of an indigenous resource, bioenergy
2. Reduction in greenhouse gas emissions through the development of carbon-neutral bioenergy systems
3. Diversification of Irish agricultural income opportunities - creation of employment or economic development in rural areas
4. Meeting national & EU policy targets for development of the renewable energy sector

There are a number of key policies at international, European and national level driving the development of bioenergy systems in Ireland. These include the Kyoto Protocol, EU directives on electricity from renewable energy and biofuels, waste management and water quality Directives and the Irish National Climate Change Strategy and Green Paper on Sustainable Energy. National policies such as the recently introduced MOTR (Motor Oil Tax Relief) scheme and the award of permission to eight companies to produce and market excise-free vehicle biofuels are indicative of the enabling environment that is developing for bioenergy in Ireland.

Over 92% of respondents (n=89) indicated that plant-based bioenergy should play a role in meeting Ireland's future energy needs. A further 5.6% of respondents did not know and 2.2% (2 respondents) were of the opinion that plant-based bioenergy should not play a role in meeting Ireland's future energy needs. The positive respondents were asked to indicate what specific role plant-based bioenergy should play and the following are the roles suggested:

- Ensuring that an appropriate balance between the loss of food productive land to biofuel production is set against the need to reduce global warming. In this context, biofuels can certainly contribute to transport and to production of electricity
- Biofuels for heat, electricity and transport.
- Biofuels to help reduce imports and dependency on fossil fuels

- Plant based bioenergy should form part of a platform of sustainable energy resources including also wind, hydro, wave and if necessary nuclear.
- Research into yield enhancing of energy crops.
- Necessary to identify alternative green energy sources (e.g. oil seed, elephant grass etc.).. and a reduced dependency on oil.
- Primary role would be as a replacement fuel for motor transport. There are several international precedents, particularly Brazil where bioenergy plays a central role in transport fuel.
- Plant based bioenergy has the potential to contribute significantly to Ireland's energy needs. This can be as electricity (normally as combined heat and power). Oil crops could be important in the production of biofuels
- Both as bioenergy and as source of chemicals through biorefineries. Biodiesel should not be favoured as energy inputs for yield are too high.
- Security of national/EU energy supply and diversification of agricultural income
- Ireland's capacity to produce bioenergy can be greatly enhanced by developing robust productive energy crop systems.

When asked whether there should be increased funding for research on plant-based bioenergy in Ireland, 92% of respondents (n=89) indicated that there should be, while 4.5% (4 respondents) did not know and 3.4% (3 respondents) said there should not be increased funding for plant-based bioenergy research in Ireland.

The survey recipients were also asked whether there is a need for a National Multi-stakeholder Research Initiative on Plant-Based Bioenergy in Ireland. Over 77% of respondents (n=88) indicated that there was a need for such an initiative, while 3.4% said there was not a need, and over 19% or respondents did not know.

Goal 3.2: Plant-based pharmaceutical and diagnostic products

The prevention and treatment of disease is one of the most compelling challenges facing humanity. To ensure the health of our species, effective new medicines should be identified, tested and produced cost-effectively. Plants already represent a valuable resource for natural medicinal products, as well as in the production of pharmaceuticals. This plant-based renewable resource is set to increasingly underpin the future of medicine – as a source of natural medicinal products and as a source of medicinal proteins for pharmaceuticals.

In this goal, as in the preceding goals, it is essential to improve the efficiency of plant production and industrial use of existing medicinal products, as well as to expand the product range, both through building on the plant's own metabolic pathways and through the use of the plants in GM applications to make therapeutic proteins and vaccines. In addition, plants have a largely untapped potential for mass-producing diagnostics competitively, and for the monitoring and bioremediation of environmental pollutants.

Deliverables and research activities include:

- To manufacture proteins at high yield for (1) new vaccines, for diseases, such as hepatitis B, human papilloma virus, hepatitis C and influenza; (2) monoclonal antibodies, against HIV/AIDS and cancer, (3) other therapeutic proteins, such as HIV microbiocides, peptide drugs, blood proteins and collagens. A key research issue is how to increase rapid large-scale production of the recombinant proteins using GM technologies in scalable containment systems, such as fermenters, hydroponic systems and greenhouse containment, as well as under cGMP.
- Understanding of the factors contributing to flux through the many pathways of secondary metabolism is essential to realising the potential of natural medicinals and antimicrobials delivered through plants. Better understanding of the biology and molecular function of the glandular organs of the plant, including trichomes, which are involved in the production of many medicinal compounds.
- Exploit the potentials of the plant cell factory to deliver diagnostics, such as monoclonal antibodies, on an industrial scale.
- Exploit the exquisite sensitivity of plants to monitor changes to their environments and respond to the stimuli with speed through 'technical plants' to be developed for monitoring purposes, acting as diagnostic biosensors for a wide range of chemical entities.
- Increase molecular understanding of the plant detoxification pathways and how these can be combined in GM applications to increase the efficiency of uptake of environmental pollutants, such as explosives and chlorinated phenolics.

Over 96% of respondents (n=86) agreed with goal 3.2. with 3.5% disagreeing with the goal for the following reasons:

- Not enough information
- There is a major shift in the Pharma industry towards bio-based pharmaceuticals and it is not clear what role plants will play in this.
- I do agree with the goal, but only with the 'production of Pharma' part of it. We are already a major manufacturer of pharmaceutical products and should develop the competence to produce pharmaceuticals in plants. I do not agree that we should make extraction of plant medicines a priority. We do not have a major resource of flora from which to extract candidates, and there are higher priorities for our small resource of plant researchers.

The relative priorities of goal 3.2 for plant research in Ireland and EU are presented in Appendix 12a & 12b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=87), and 27.5% indicated that there were, while 69% did not know and 3.4% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Vaccine and adjuvant production in plants (Dr. Jackie Nugent and Prof. P. Dix, NUIM)

- Antibody production in plants (Prof. Tony Kavanagh, TCD)
- Oral vaccine production in plants (Dr. Charlie Spillane, UCC).
- Pharming of proteins in Lemna spp (Dr. Marcel Jansenm UCC).
- Secondary metabolite research in tissue culture (Graham Wilson, UCD)
- Extraction of antimicrobials & anti-cancer 2o metabolite compounds from plants (Prof Franklin Smyth & Prof Ian Rowland, University of Ulster, Coleraine).
- Extraction of bioactives from plants (Prof Ingrid Hook, TCD).

The respondents (n=84) were asked whether there are other plant research priorities for Goal 3.2 at national or European levels. While 75-74% did not know, 13-13%% indicated that there were no additional priorities relating to goal 3.2 while 12-13% indicated that there were additional priorities for goal 3.2. These included:

- Genetic modification of crop plants that are already highly productive to enable them to produce useful secondary compounds
- Using non-GMO based-approaches.
- Plants as sources of chemicals other than pharmaceutical industry. Can use biorefineries to provide essential fatty acids used in plastics etc.
- Edible vaccine development
- Screening of native plants for pharmaceutical activity is still worthwhile

Challenge four: Competitiveness, consumer choice and governance

The successful implementation of the objectives outlined in the previous three challenges of this Strategic Research Agenda depends on a strong European research and resource base: vibrant basic research, skilled and mobile researchers, and access to key research infrastructures.

Vibrant basic research is essential for EU competitiveness, and the Technology Platform's sustainability, innovation, and consumer choice goals are critically dependent on knowledge, tools and technologies derived from basic research. Such knowledge will be critical to fulfilling our goals of securing healthy, nutritious and safe food, developing valuable 'green' products, as well as making agriculture and landscape management more sustainable.

The Technology Platform intends to focus on a number of goals to meet the issues in this challenge:

1. Vibrant basic research
2. Human resources, infrastructure and networking
3. Public and consumer involvement
4. Ethics, safety, legal and financial environment

Goal 4.1: Vibrant basic research

The cutting edge of basic plant research is rapidly evolving from understanding the function of single genes to more "holistic" approaches studying networks of genes that control biological processes. This new era of integrative biology enables us to determine how the interconnected networks of genes work together in complex biological processes, how natural genetic variation creates biodiversity. This should ultimately lead to a paradigm shift in how we breed plants, enabling the rational breeding of plant traits. Such basic research is likely to target four deliverables:

Goal 4.1.1 Genome sequencing and biodiversity

Genome sequences are one of the primary frameworks furnishing basic knowledge of a species. Over 95% of the respondents agreed with goal 4.1.1. while 4.7% disagreed because they felt there were other priorities (1 respondent) or they considered it very expensive work providing little information (1 respondent).

The relative priorities of goal 4.1.1 for plant research in Ireland and EU are presented in Appendix 13a & 13b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=85), and 27.1% indicated that there were,

while 67.1% did not know and 5.9% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Dr. Charles Spillane (UCC) is developing plant genomics platforms that can be applied to any plant (or animal species).
- Dr. Douwe Van Sinderen (UCC) and colleagues are conducting genome sequencing projects on bacteria.
- Ireland has a wealth of talented bioinformatics researchers who have recently began focussing some of their effort on plant genomes (e.g. Dr. Aoife McLysaght TCD, Prof Ken Wolfe TCD, Mary O' Connell (DCU), and Dr. Aaron Golden NUIG).
- Dr. Dan Milbourne (TEAGASC, OakPark) is linked to potato genome sequencing efforts.
- It was stated that the model plant *Arabidopsis thaliana* should be an integral part of the proposed national Systems biology Institute.

The respondents (n=80) were asked whether there are other plant research priorities for Goal 4.1.1 at national or European levels. While 80-78% did not know, 14-12%% indicated that there were no additional priorities relating to goal 2.3 while 6-10% indicated that there were additional priorities for goal 4.1.1. These were based on the following comments:

- As the cost of DNA sequencing is dropping dramatically, there is potential for Ireland to take some leadership in plant genome sequencing and population genomics that would build on Ireland's strong position in bioinformatics.
- Plant model organisms such as Arabidopsis provide an ideal platform for systems biology initiatives to understand relationships between genotype-environment, and between genome, proteome, metabolome and functioning of the organisms.
- Vibrant basic research may not be a means in and of itself. Research should also include working on an interdisciplinary basis to share scientific knowledge in an effective manner.
- Better consultation models with public on all aspects of GM and genomic research.
- Genome sequences are only one of the frameworks - there are many others - at the molecular level the interaction of sequences with product is more likely to be of use.

Goal 4.1.2: Undertake plant systems biology

There are currently efforts underway to establish a large scale Systems Biology Initiative in Ireland. At the very core of systems biology is the goal of being able to model a living organism. Plant systems biology therefore aims to understand how multiple genes function in concert to affect key processes in plant development and environmental interactions, metabolism and physiology.

Systems biology examines the structure and dynamics of cellular and organismal function, rather than the characteristics of isolated parts of a cell or organism. The major reason systems biology is gaining interest today is that progress in molecular biology, particularly in genomics, proteomics, and high-throughput measurements, is enabling scientists to collect comprehensive data sets on the mechanisms underlying plant growth and plant responses to perturbations. The new high-throughput tools of genomics have provided biologists with the potential to systematically perturb and monitor biological systems while they are functioning. With the wealth of information provided by these new approaches, plant biological research is becoming more reliant on informational science. This interaction of plant molecular biology with informational sciences will help pinpoint which types of experimental analyses and measurements need to be made.

Systems biology requires quantitative data that are high quality and comprehensive. Comprehensiveness in systems biology requires three types of measurements. First, we need to measure the expression levels of a large number of mRNAs, proteins, structural polymers, and metabolites simultaneously. Second, we need to heighten the temporal resolution of such molecular changes to model dynamic changes. Third, we need to spatially resolve where these changes are occurring in the plant at the level of the cell type. To expedite the collection of comprehensive and accurate data, technical innovations in high-throughput experimental measurement including microscopy and robotics need to be fostered. To design these new high-throughput tools, plant biologists will have to work side by side with engineers who design and operate high-precision and high-throughput measurement systems.

Over 95% of respondents (n=83) agreed with this goal while 4.8% (4 respondents) were not in agreement, for the following reasons:

- Any approach to genomic based research should be approached very openly and carefully with full consideration for the ethical implications.
- Don't' see it as very relevant

The relative priorities of goal 4.1.2 for plant research in Ireland and EU are presented in Appendix 14a & 14b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=84), and 19% indicated that there were, while 76.2% did not know and 4.8% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- While systems biology is currently considered as a priority area for Ireland, there has been no consideration that plant systems biology should be one or the major component of a national systems biology institute. This simply reflects the low appreciation in current funding bodies and govt decision makers for the strategic relevance of plant R & D to the economy and society of Ireland.
- Plant genome & genomics research of Dr. Charlie Spillane (UCC) and Prof Tony Kavanagh (TCD).
- Plant microarray research by Dr. Fiona Doohan (UCD) & Dr. Paul McCabe (UCD)

- Plant genome bioinformatics and molecular evolution of Prof Ken Wolfe (TCD) & Dr. Aoife McLysaght (TCD)

The respondents (n=81) were asked whether there are other plant research priorities for Goal 4.1.2 at national or European levels. While 82-83% did not know, 13-11%% indicated that there were no additional priorities relating to goal 4.12 while 5-6% indicated that there were additional priorities for goal 4.1.2. The additional priorities were only specified by one respondent who stated that greater public consultation was an additional priority:

Goal 4.1.3: Develop improved research tools and processes

The development of new improved research tools and processes is necessary as it has been shown that advances in biotechnology and genomics are strongly driven by technological innovation.

Of the 84 respondents who were asked if they agreed with goal 1.3, 94% were in agreement while 6% (5 respondents) were not in agreement for the following reasons:

- There were genes before humans, technological innovation has allowed us to tinker with what occurred before we were human.
- Public concerns should also contribute policy on biotech and genomic research.
- Development of improved research tools and processes not a priority
- Need funding to understand some of the fundamental questions rather than continually playing with new technology.

The relative priorities of goal 4.1.3 for plant research in Ireland and EU are presented in Appendix 15a & 15b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=85), and 22.4% indicated that there were, while 71.8% did not know and 5.9% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Arabidopsis molecular genetics & genomics research in Ireland (Prof Tony Kavanagh, TCD; Dr. Charlie Spillane, UCC and Dr. Jim Provan, QUB, Belfast).
- Research activities at the TEAGASC Crop Biotechnology Unit, OakPark, Carlow.
- Ireland lags behind other nations in the development of improved research tools and processes for plant genomics and biotechnology.

The respondents (n=82) were asked whether there are other plant research priorities for Goal 4.1.3 at national or European levels. While 82-82% did not know, 14-12%% indicated that there were no additional priorities relating to goal 4.1.3 while 4-6% indicated that there were additional priorities for goal 4.1.3. The additional priorities were:

- Development of fusions of plant genomics and metabolomics research with nanotechnology and photonics research
- Greater public participation in research policy process and better understanding from biotech industry about bioethics and the many social issues that all biotech raises.

Goal 4.1.4: Develop improved genetic systems for crop improvement

Develop improved genetic systems for crop improvement, as systems biology research into basic biological processes in model species should be translated to relevant traits in key crops by delineating the molecular basis of genetic systems underpinning crop improvement and innovative agricultural practices. The study of these genetic systems should allow the prediction of 'real world' performance from laboratory studies.

Of the 83 respondents who were asked if they agreed with this goal, 88% were in agreement while 12% were not in agreement for the following reasons:

- It would be an acceptable goal if it contained a balance with regard to potential negative impacts
- Would need to be explained in greater detail.
- This questions masks an involvement in genetic manipulation (GMOs)
- Suspect you are talking about genetic modification here. This is the most expensive approach and the systems are likely to be so complex that success is unlikely.
- The systems biology approach is still an order of magnitude too simple

The relative priorities of goal 4.1.4 for plant research in Ireland and EU are presented in Appendix 16a & 16b). The respondents were asked whether there are plant R & D activities underway for this goal in Ireland (n=83), and 14.4% indicated that there were, while 79.5% did not know and 6% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Plant molecular genetics research (Prof Tony Kavanagh, TCD; Dr. Charlie Spillane, UCC; Dr. Max Dow, UCC; NUI Maynooth; TEAGASC OakPark Plant Biotechnology Unit).

The respondents (n=80) were asked whether there are other plant research priorities for Goal 4.1.4 at national or European levels. While 82-80% did not know, 14-12% indicated that there were no additional priorities relating to goal 4.1.4 while 4-8% indicated that there were additional priorities for goal 4.1.4. The additional priorities were:

- All stakeholders would need to be aware of what "systems biology research" & what "can be translated into relevant traits in key crops" means.

- To achieve this goal using non-GMO based methods.

Goal 4.2: Improving human resources, infrastructure and networking

Rapidly evolving fields of science and technology are typically driven by the best young and talented scientists. The proper nurturing of young and talented scientists through training and mobility opportunities is a critical success factor for the competitiveness of plant research in Europe.

Of the 85 respondents, almost 99% were in favour of the goal of improving human resources, infrastructure and networking for plant research in Europe. One respondent (1,2%) was not in favour because they felt that there is no point in nurturing young and talented scientists if there is no proper career structure for them to feed into.

The relative priorities of goal 4.2 for plant research in Ireland and EU are presented in Appendix 17a & 17b). The respondents (n=85) were asked whether Ireland currently has sufficient scientific expertise in advanced plant research. While almost 45% of respondents did not know, almost 46% of respondents stated that Ireland current does not have sufficient scientific expertise in advanced plant research. Only 9.4% of respondents were of the opinion that Ireland currently has sufficient scientific expertise in advanced plant research. The reasons respondents cited why Ireland does not have sufficient scientific expertise were:

- There is no national graduate school in plant R & D. The plant researcher community in Ireland is fragmented and isolated from its counterpart communities both in the UK and mainland Europe. Unless Ireland's universities and funding bodies make a concerted effort in terms of funding and planning, Ireland will continue to entrench itself towards an incredibly weak position in advanced plant research. Given the opportunities that plant R & D offers to Ireland over the longer term such lack of investment and focus (relative to the biomedical sector) is unwise.
- It has not been a research priority of the major funding bodies in Ireland - limited funding to support plant research, infrastructure and training
- There is no specificity of plant sciences studies
- Ireland, like the UK, has suffered from the flight from plant GM, with a loss of trained workers to the USA and elsewhere. If we are serious about these objectives we need to train and retain more plant scientists
- Our education system is not focusing on the biological sciences because of inadequate teachers and facilities.
- There has been a greater emphasis on animal science in the past
- As we live in Europe, this is a matter of attracting top-researchers.

- While there are sufficient recently qualified biotechnology graduates, they need more time to develop expertise in the various disciplines.
- We find it very difficult to interest good students in basic plant science. This is a worldwide problem which needs to be tackled globally as well as nationally.
- The best have to leave to find real jobs in plant science... especially in the molecular side of things there are NO research jobs in Ireland.
- Lack of strong career paths (most young scientists are on short term contracts). This leads to less opportunity to become real 'experts' in their field. Third level teaching of science has moved away from a systematics approach. In a few years there will be a gross shortage of taxonomists, those with diagnostic skills and those with meaningful overviews.
- Employment opportunities are fairly minimal in the plant research area in Ireland.
- Not enough interest from funding agencies, i.e. NDP is the main source of funding, and its focus is not on this area, so no-one gets funded.
- Not enough researchers in the relevant fields
- The development of the biotech centres in UCD and Teagasc, and the success of companies such as Identikit have seen a huge development in Irish capacity in the past ten years. However, the advances in other countries are moving very quickly. Many research proposals in Ireland look at re-doing research from other places, the more favourable option would be to take a novel research idea and progress it.
- Insufficient funding and career structures. Over-reliance on PhD students as the basis for national researcher capacity.
- National funding is focussed at human/animal systems or IT. Plant research through SFI support is minimal. EPA, Teagasc and IRCSET have been major funding bodies for plant research in Ireland over past few years, but primary funding would still be from EU Framework programmes.
- Ireland does not have sufficient scientific expertise in any scientific discipline
- I can't explain why this has occurred, but it is clear that it is still a small area of activity within a biological research sector which is dramatically expanding.
- Not enough very good students chose plant biology for an in depth study. - not so many possibilities for postdocs and graduate students in plant biology.
- Advanced plant research depends heavily on molecular biology approaches; there is currently not sufficient expertise in plant molecular biology in Ireland
- Because it is a very specialised field with no direct access.
- Few jobs, poor 2nd level profile, limited 3rd and 4th level opportunities.
- This is a new and emerging area of research interest within Ireland. While some research has been ongoing, it has not been a national priority and consequently there has not been high levels of investment in this area.
- Can you ever have sufficient? Specific plant funding streams need to be established rather than having grants assessed by researchers from animal field with a poor understanding of plant biology
- A few critical areas are lacking expertise.

The respondents were asked whether they think that plant research can improve Ireland's economic competitiveness. Over 82% of respondents (n=85) believed that plant research

expertise can improve Ireland's economic competitiveness, while only 2.4% felt that it would not. Over 15% of respondents did not know.

The respondents were asked whether there are plant R & D activities underway for goal 4.2 in Ireland (n=83), and 25.3% indicated that there were, while 63.9% did not know and 10.8% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Because Ireland's community of plant researchers is fragmented, there are efforts underway to develop a National Platform on Plant Research and technology. However, there is no indication as of yet of university or funding body support for the upgrading of Ireland's plant research capacity and infrastructure. There is a need for a National Postgraduate Researcher training School, that should be part of a broader EU effort to promote excellence in plant researcher training in Europe.
- The training network is an area that requires further attention. The relay system for the dissemination of research findings coupled with increased co-operation between institutions and disciplines in Ireland and abroad will strengthen these activities.
- Is this really research, or research management/admin? There are grants, and other facilities on the lines of those indicated. If the research admin system saw that there was a clear ambition to develop a strong activity in plant biotech research, I believe that these supports would be forthcoming.
- Exchange programmes via Marie Curie Leonardo etc at all research Institutions.

The respondents (n=82) were asked whether there are other plant research priorities for Goal 4.2 at national or European levels. While 75-78% did not know, 9-9% indicated that there were no additional priorities relating to goal 4.2 while 16-14% indicated that there were additional priorities for goal 4.2. The additional priorities were:

- Ensuring that a multi-stakeholder plant research platform is established which includes funding bodies, academics, researchers, industry, farming and food bodies, NGOs and other relevant stakeholders.
- Young scientists should also be trained in greater communication with media and all publics.
- Attention also needs to be given to earlier stages in the education system, particularly at secondary level to encourage young people to pursue science at third level.
- Integrating the training for plant biotechnology with that for assessment of health benefits /safety
- Influencing young people at a early stage (14+) in plants and plant related science
- We need to provide adequate funding and a career structure for both postdocs and postgrads. The postdoc situation is particularly serious, with little career structure and reduced opportunities for permanent posts.
- Need to get more young scientists into plant research

- Young scientists have to be encouraged to pursue areas that would be considered high risk. In addition, further efforts are required to stop the massive loss of Irish PhD and masters students.
- Need for commercial interaction- interaction of business/commercial and university should be thought through better. No money for ideas at outset, SME's don't have sufficient money to initiate whereas universities want money but want hands off approach towards research
- National: Career structure and pay levels. I would not encourage any young person to go into this area of short-term contracts, poor pay and little opportunity for advancement. Postdocs are treated with contempt.
- Irish plant research is highly distributed in different centres. No single centre has sufficient activity to warrant it being a priority within their institution. If plant researchers were to agree a common strategy for joint research, it would allow national funding agencies to address the area as a single area of activity.

Capacity for Coordination at different levels

Coordination is crucial to the global competitiveness of the European research effort and to achieve the critical mass of resources needed for the realisation of the ambitious goals of the Technology Platform by overcoming the current fragmentation and duplication. This coordination is required at three different levels: between research institutions, between academia and industry and at the international level.

The respondents (n=86) were asked to indicate the level of coordination that exists between the groups in Ireland represented in Figure 10, where the results of this question are also presented. The majority of respondents indicated that they were unsure about the level of coordination in Ireland between different groups (47%-57%). The coordination between plant researchers in academia and plant researchers in government or in industry was considered to be low (17% and 25% respectively).

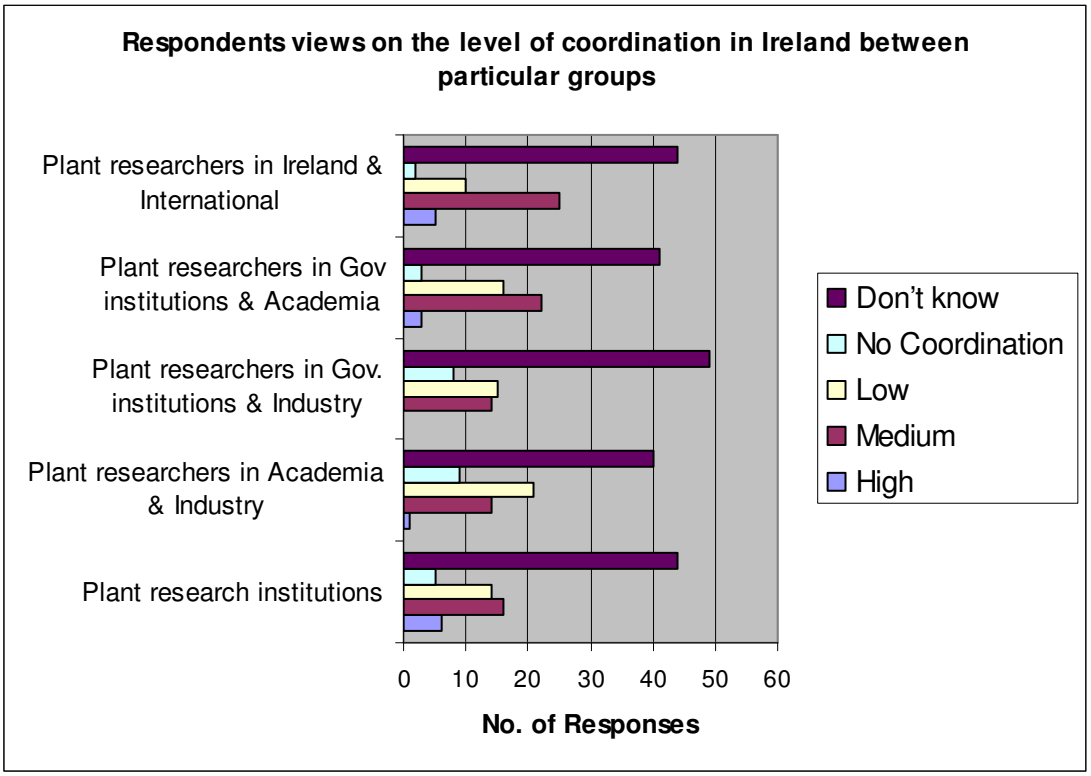


Figure 10: Respondents views on the level of coordination in Ireland between different groups.

Goal 4.3: Public and consumer involvement

A large proportion of the Technology Platform's activities will be devoted to engagement with the public. Each technical programme will have a mechanism that not only provides information but, where possible, allows the public to engage with and influence the course of events.

Research activities to achieve goal three will include:

- an increase in interest and knowledge of plants
- improvement of mutual trust between the public and the plant science community including training programmes to help researchers effectively engage with the public
- highlighting the fun aspects of plants to make plant science itself more engaging and attractive

Of the 84 respondents, almost 93% were in favour of involving the public and the consumer in Technology Platform activities. However, 7% were not in favour of this goal for the following reasons:

- Although I thoroughly approve of public engagement I think we must be very careful about the amount of influence we allow. In the UK at present, majority public opinion would stop all research on GM of crop plants (we've lost much our industrial research in this area already). This would be a disaster. So, despite the 'political correctness' of this goal, it must be tempered with common sense.
- A large proportion of public and consumer involvement seems out of proportion
- It would be fine if the public in general showed an interest and were informed. However, history shows us that the average public is not interested unless a benefit can be derived whereas special interest groups more concerned with lofty ideals would only derail good science if it went against their principles.
- Educate and engage but not influence. A little knowledge is a dangerous thing, and the public should not be allowed to proclaim themselves experts on a subject having read a subjective newspaper article.
- Science must be driven by strategy.
- The public has to be better informed before useful involvement could occur

The relative priorities of goal 4.3 for plant research in Ireland and EU are presented in Appendix 18a & 18b). The respondents (n=82) were asked whether there are R & D activities underway for this goal in Ireland, and 12.2% indicated that there were, while 82.9% did not know and 4.9% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- Website to promote the use of wild flowers by amateur gardeners, landscapers etc. (Sandro Cafolla, All Go Wild, Carlow)

- Research on how to develop models for client-participation in applied R & D. (C. Spillane & C. O' Mahony, UCC, Cork).
- Programmes to promote/encourage/foster interaction with the public and the engaging of public/public bodies in on-going research. (M. Tuohy, NUIG Galway, Marine Institiute, EPA, and FIRM).
- Long term field trial project which will introduce professionals and the public to many new ornamentals from breeders' world wide. (Fitzgerald Nurseries, Kilkenny)
- Relay workshops and associated publications are used to inform the public of outcomes of food research (RELAY, Teagasc , Fermoy)
- There have been several activities in the past to involve the public in the GM debate. They have been useful and should be continued, although they are highly susceptible to being manipulated by anti-GM groups

The respondents (n=80) were asked whether there are other plant research priorities for Goal 4.3 at National or European levels. While 64-65% did not know, 9-11% indicated that there were no additional priorities relating to goal 4.3 while 8-10% indicated that there were additional priorities for goal 4.3. These included:

- European - broaden the involvement of stakeholders beyond industry and give R & D client groups a say in national/EU funding decisions. Such client/stakeholder groups should be representative and fully accountable to their membership bases in terms of what plant research they promote.
- Public engagement does not mean just building greater trust or 'making plants fun.' All publics need to be given active role in deciding policy, using advocacy models (e.g. as in Nordic countries)
- True informed participation from politicians.
- Research needs to be made to discover how willing the public are to engage with plants and be educated about plants more.
- Should include public information on ethics and risk assessment (both benefits and risks).
- Recent food safety scares have greatly increased consumer awareness and familiarity with many of the issues discussed previously. Interaction with the public will need to recognise the generally high level of education and knowledge which now exists among the general population and cannot take a patronising or overly simplistic approach. Education aimed at children will also be important to raise awareness of health issues related to food and also to try to encourage an interest in a career in plant science.

Goal 4.4: Ethics, safety, legal and financial environment

The Technology Platform proposes to improve dialogue and actions around ethics and considerations and actions leading to a legal and regulatory environment providing for safety, consumer choice, coexistence of different farming practices and intellectual property rights, and a financial environment encouraging entrepreneurs and industry to invest in plant science research and development.

Research activities to achieve goal four will include:

- an increase in dialogue around the ethics and choice for the consumer in relation to growing food and feed
- research in options for crop management
- improvement in existing and developing new technologies reducing gene flow
- improvement in investment in plant research at all levels through better coordination of public funding and creation of public/private partnerships to utilise private funding

Of the 84 respondents, 92.9% were in favour of goal 4.4 while 7.1% did not support this goal. The reasons given for not supporting goal 4.4 were:

- Intellectual Property Rights should belong to a global plant health organisation, who should then lease out the rights to industry and end users.
- It needs to be balanced with some reference to the 'common good'
- Dialogue and actions centred around ethics, safety, consumer choice, coexistence of different farming practices I agree with, but more discussion needed on patenting. Excess entrepreneurship could lead to problems with sustainability and contacts with developing countries.
- Appears to have GMO focus.
- Ethics should be discussed by independent committees, not scientists paid by bioindustries! Better coordination of research is of extreme importance: public/private, Ireland/Europe

The relative priorities of goal 4.4 for plant research in Ireland and EU are presented in Appendix 19a & 19b). The respondents (n=83) were asked whether there are R & D activities underway for this goal in Ireland, and 6% indicated that there were, while 81.9% did not know and 4.8% stated that there were none underway. R & D activities underway for this goal in Ireland included:

- UCD PhD research on IPRs in crop plants
- Agricultural biotechnology policy research (IPRs, biosafety, equity) of Dr. Charlie Spillane, UCC.
- Irish national bioethics committee have developed document on GM crops.
- Work by Dept of Agriculture, Teagasc, EPA and Food Safety Authority

- Current Crop management: Applied Plant Science, DARDNI, Newforge Lane, Belfast
- Teagasc research looking into gene flow and aspects associated with co-existence under Dr E Mullin.

Intellectual Property Rights & Plant Research

The Irish Council for Science Technology & Innovation recently developed a National Code of Practice for Managing Intellectual Property from Publicly Funded Research. The Code addresses each aspect of the management and transfer of research and development results from universities, institutes of technology and public research institutions to the commercial market place.

The respondents were asked whether they were aware of the National Code of Practice for Managing Intellectual Property from Publicly Funded Research? Of the 85 Respondents, 69.4% indicated that they were aware of the National Code of Practice for Managing Intellectual Property from Publicly Funded Research, while 30.6% indicated that they were unaware.

The respondents were further asked whether they had read the National Code of Practice for Managing Intellectual Property from Publicly Funded Research. Of the 85 respondents, only 14.1% indicated that they had read the Code, while 85.9% indicated that they had not read the Code.

The respondents were asked whether the outputs of publicly-funded plant research in Ireland should be protected by intellectual property rights (e.g. patents, plant breeders' rights, trademarks, copyright)? For this question, 56.5% of respondents (n=85) were in support of the outputs of publicly-funded plant research being protected by intellectual property right, while 32.9% were not in support and 10.6% were unsure. The reasons given for not placing IP protection on publicly-funded plant research included:

- Taxpayer funded research should not be subject to exclusive licensing to private companies. IPRs are a strategic business tool. The universities and public research institutions do not know how to manage IPRs as a strategic business tool because they are not private companies. It would be simpler, cheaper and make a more level playing field if publicly funded research was openly and publicly available to all.
- This is too sweeping a question, the issue of the common good is complex but needs to be factored in.
- More conversation needed on patenting and IP laws for scientific research particularly genomic output.
- Not clear from wording of question if the state and therefore the taxpayers would benefit, which I think they should from results of publicly funded research.
- I think the rights for anything developed with the aid of public funding should be for the general public and not be granted to any individual or company

- Seems obvious that if the taxpayer pays for it (including me!) they should get the benefit without additional costs which are inevitable with IPR
- While IPRs should be available to encourage investment in research there are also concerns in relation to IPRs being claimed over wild species which would reduce access to traditional varieties.
- Research funded by the public should be made available to the public or at least for other Irish institutions.
- Publicly funded research outputs should be available to the public who in effect have already paid for it.
- All gains of publicly funded research should be available to the public that paid for it.
- Publicly funded research should be protected by property rights for the public who pay for it! So would the funding body (EU or Ireland) retain the rights and sell or license the outcome for the 'public good'?
- Information has been funded through tax payers' money. Information should be freely available.
- 100% publicly-funded research should be public.
- Because a researchers needs to publish freely some research outcome might be considered to be protected, but mostly it is more hindering the research by blocking publications and therefore acquiring further external funding
- The outputs should be available widely. This can help further beneficial developments based on these outputs.
- If publicly funded it should benefit all.
- Research was funded publicly therefore outputs should remain public.
- Because it's public property.
- Yes, if only to prevent others claiming such IPR. But whether royalties are actually charged or not may depend on particular circumstances. Protection for breeders' rights should apply.
- No, in the sense that the funder (i.e. public) should have a stake hold in such rights.

The respondents were asked whether the outputs of privately-funded research in Ireland should be protected by intellectual property rights (e.g. patents, plant breeders' rights, trademarks, copyright)? For this question, 72.9% of respondents (n=85) were in favour of the outputs of privately-funded plant research being protected by intellectual property right, while 14.1% were against and 12.9% were unsure. Comments provided by those opposed to placing IP protection on privately-funded plant research included:

- Investors have a right to a return on their investments and IPRs were developed as a tool to incentivise private funding of research.
- They belong to the human race. Only the end product should be privately owned not the intellectual property rights, as students are funded by the government who then work for private industry.
- More conversation needed on patenting and IP laws for scientific research particularly genomic output.

- It depends on the nature of the research and the product
- My answer is YES, I think they should, but surely this is only the business of the funder.

Plant Research and Developing Countries

Development Cooperation Ireland (DCI) is the Government of Ireland's programme of assistance to developing countries. Ireland has had an official development assistance programme since 1974. It has grown steadily over the years from modest beginnings to its current size (total Overseas Development Aid (ODA) in 2005 is 545 million euros). Since its inception in 1974, the DCI programme has had a strong geographic focus on Sub-Saharan Africa , namely Lesotho, Mozambique, Tanzania, Ethiopia, Zambia and Uganda. These are termed "Programme Countries".

The respondents were asked whether Ireland should support plant research partnerships for poverty reduction in Ireland's Programme Countries? Of the 84 respondents to this question, 92.9% were in favour of Ireland supporting plant research partnerships for poverty reduction in Ireland's Programme Countries, while 1.2% was against this and 6% were unsure. Reasons for not supporting this goal included:

- Plant Sciences should be properly funded! If based on merits (value for money) DCI money ends up on the plant science, that's OK. But it does not take away the requirements of dedicated funding for plant scientists.

Ireland has an objective to contribute 0.7% of GDP to overseas development aid by 2013. The Irish Government has allocated 2500 million euros for Research, Technology and Innovation activities in the National Development Plan (2000-2006).

Respondents were asked whether Ireland should spend 0.7% of its overall plant R & D expenditure on plant research of relevance to its Programme Countries in Africa? For this question, 71.8% of Respondents (n=85) indicated their support of the proposal that Ireland could spend 0.7% of its overall plant R & D expenditure on plant research of relevance to its Programme countries in Africa, while 8.3% were not in support of this idea and 20% were unsure. The reasons given by those opposed to spending 0.7% of Ireland's overall plant R & D expenditure on plant research for DCI Programme countries were:

- Ireland needs to sort their problems out first as it is still under significant development
- No! We should spend a lot more than 0.7% when it comes to food R & D
- Ireland should spend 1%.
- I don't know where this number came from.
- Depends which budget it comes out of. Should be additional to Irish R&D funding, not siphoned from existing R&D budget.

The respondents were asked whether Ireland should contribute financially to initiatives that increase collaboration between researchers in Ireland's partner countries and Irish plant researchers? Of the 85 respondents to this question, 89.4% agreed that Ireland should contribute financially to initiatives that increase collaboration between researchers in Ireland's partner countries and Irish plant researchers, while 2.4% disagreed and 8.2% were unsure. Reasons given by those not in support included:

- I think it should, however the issue of IPRs would come into play when there is such partnership. There would need to be appropriate protections in place to ensure that the results of such research benefit agriculture in programme countries and not merely bring financial benefit to the Irish partners, particularly in the private sector.
- While it is a good initiative, I think we should concentrate in the short-term on developing the base of researchers in Ireland. When it is developed, we can help others to do so.

National Capacity for Plant Research in Ireland

The advanced plant research capacity in Ireland of relevance to the Plants for the Future Technology Platform is currently fragmented across multiple universities and government research institutions (e.g. TEAGASC).

There are at least 30+ research groups/labs in Ireland working on plant genetics & biotechnology (basic, agricultural, forestry, algae, ecology, biodiversity, genetic resources, nutrition, and pharmacological), including genomics, genetics, breeding, molecular biology, natural products chemistry and metabolomics.

In other countries with a similar distribution of plant research capacity, there have been successful initiatives to pool existing plant (or other) research expertise under the common umbrella of a National Platform and thereby assemble critical research mass. Examples of national research & training 'platforms' include:

- Zurich-Basel Plant Science Center (3 universities, 1 research institute, 20+ research groups)
- Plant Science Scotland
- Virtual Institute of Bioinformatics Eire (VIBE) – (11+ research groups)
- Ireland's National Platform for Biodiversity Research – (forum for dedicated funding windows for biodiversity research in Ireland)
- Dublin Molecular Medicine Center (DMMC) – (3 universities, 6 hospitals)
- Flanders Interuniversity Institute for Biotechnology - (850 scientists, 4 universities)

National Multi-stakeholder Platform/Coalition for Plant Research in Ireland

The respondents (n=82) were asked whether there is a need for a National Multi-stakeholder Platform/Coalition for Plant Research in Ireland? Of the 82 respondents who answered this question, 76.8% of Respondents (n=82) agreed that there was a need for a National Platform for plant research in Ireland, while 23.2% were unsure. There were no respondents opposed to the development of a National Multi-stakeholder Platform/Coalition for Plant Research in Ireland.

The respondents (n=81) were asked to rank the relative importance of a range of objectives in the event of a National Platform. The range of objectives were:

> 1) Developing a National Postgraduate Graduate Training School in Plant Research & Technology
> (2) Promoting scientific exchange and co-operation between the participating research groups
> (3) Planning and carrying out innovative, complex & interdisciplinary projects at a high scientific level
> (4) Increasing knowledge about plants and the organisms with which they interact, from the molecular level to the level of the ecosystem
> (5) Applying the findings of basic research
> (6) Intensifying co-operation with business, politics, and government and other stakeholders
> (7) Increasing visibility with business, politics, and government and other stakeholders
> (8) Encouraging dialogue with the public
> (9) Contributing a scientific point of view to social, economic, and political topics and (10) Sharing and pooling of plant research infrastructure (e.g. greenhouses, gardeners, technicians, core facilities, growth rooms, and research equipment).

Overall, the majority of respondents (n=81) indicated their support for different objectives for the creation of a National Platform for plant research. This level of support ranged from 57%-83% with the specific levels of support for each objective highlighted in Figure 11.

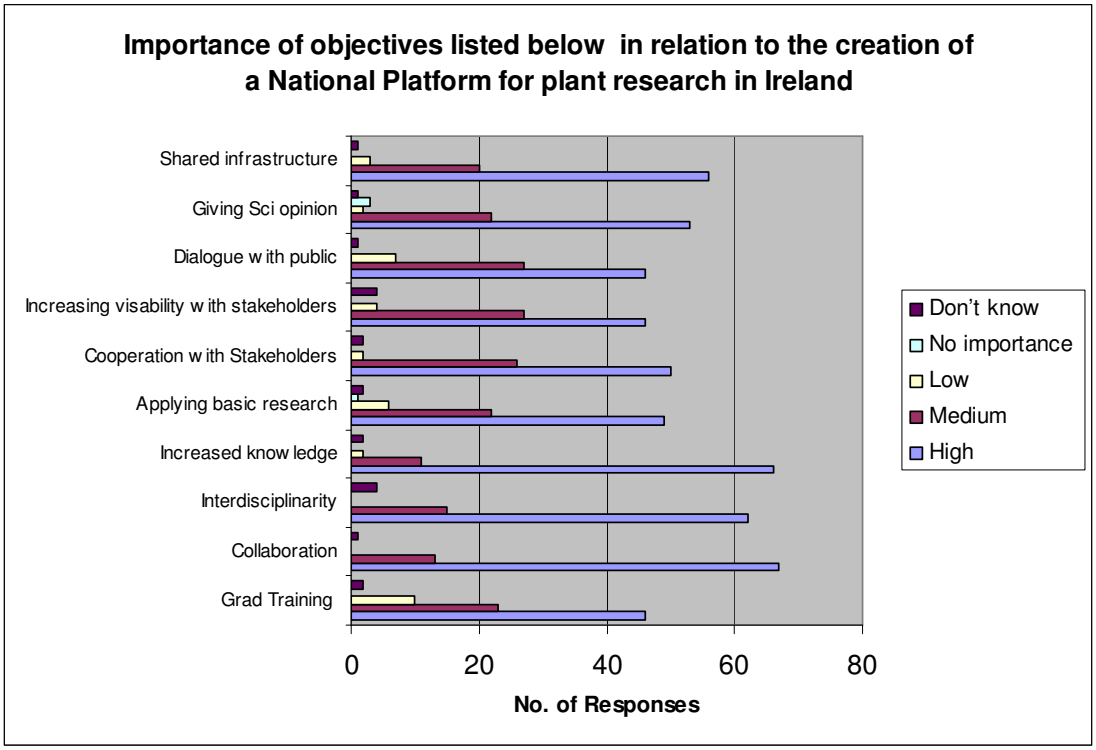


Figure 11: Respondents views on the relative importance of objectives relevant to the creation of a National Platform for plant research in Ireland.

Some comments from respondents in relation to the National Platform include:

- As there are max 30 plant research groups in Ireland with potential to contribute to the Plants for the Future research agenda, these groups should consider that much more is to be gained through a national umbrella cooperative approach than continuing the current fragmented approach to plant research in Ireland.
- Would really encourage such an initiative and would be keen to contribute/participate/have my group actively involved and to promote the activities of such an initiative in the public domain.
- A nationally integrated approach would maximise the return on resources invested and help retain/attract the best people.
- National Platform needs to include many stakeholders that do not just come from scientific or financial sectors. Academics, environmentalists, ethicists, social scientists also as well as members of the 'general public.'
- If this can be got off the ground it will be an excellent way of coordinating plant research, achieving greater efficiency of effort and expenditure and attracting funds.
- A virtual school might help give Irish Plant Scientists a face to the outside world.
- The national platform needs to have as wide as possible representation and should not be linked to any state/semi-state organisation or funding body. This could then act as an independent voice to support Irish plant science, particularly in the EU. Representation on relevant EU committees and funding bodies could also be explored.

- I think this would be crucial to make the plant research community visible - coming from outside that community (but within the national policymaking system) in my opinion they are underrepresented. Without a concerted effort to change this situation it will be very difficult for plant researchers. A crucial aspect of building a National Platform will be to integrate it with existing national capabilities. This will entail active collaboration/association with one or more existing PRTLI funded centres in Ireland and the build up of a core number of SFI funded Principal Investigators. The National Platform should strive to enhance links with European partners given that specific plant research expertise at high critical mass will only be available outside Ireland during the crucial early development stages. Framework Programme funding will be relevant here.
- A good idea but would need careful management for maximum efficiency and benefit.
- Cooperation is the only way forward in a small country with limited resources. Good science comes from good ideas well implemented, not bad ideas followed by lots of researchers. Competition within Ireland should be increased, but not only in specific areas i.e. NDP related. Basic research is the only way to build a strong foundation, and sometimes basis research is just that, basic.
- Include seaweed and preferably include Industry players at that platform. Tends to be led by academic and civil servant to exclusion of Industry. Should be focused on good science and the commercialisation of good science for benefit of Ireland. Platforms should work out guidelines specifically for publication mechanisms-retain commercial edge and protection of IP. Coordination: No coordination with Enterprise Ireland between Universities - need to refocus existing resource. No need for new plant researcher coordinator but rather increased dialogue between them all, bit of commercial reality and focus.
- This is the only way to go for Ireland. It has huge challenges in its implementation but there is no alternative for survival of cutting edge plant research in this country. Start with a small visionary group that has the credibility to carry the community with them.
- At the risk of repeating myself, a single national organisation would have many advantages including those above. A major one would be the ability to convince national agencies that there was a concerted effort by a diverse group of researchers to operate as a unit towards specific goals. A model might be the DMMC-like structure between several agencies to form an Irish Plant Molecular Biology Centre.
- National Platform for Plant Research in Ireland would be very worthwhile and is currently needed to strengthen plant research in Ireland. It may encourage foreign researchers to come to Ireland as well as bringing back Irish plant researchers who had to find jobs abroad**.**

Overall recommendations/findings

10. The majority (consistently over 90%) of respondents were in support of all of the challenges and goals presented for the Plants for the Future technology Platform (TP), Strategic Research Agenda (SRA) and Action Plan.

11. At present, there seems to be little consensus amongst stakeholders on whether Ireland has sufficient research capacity in advanced plant research and development to meet its future needs.

12. Advanced plant research capacity in Ireland (of relevance to the Plants for the Future TP) is currently very low and fragmented across universities and research institutes such as TEAGASC.

13. Lack of strategic funding & planning for improving the quantity, quality and relevance of plant R & D in Ireland has prevented Ireland from developing sufficient plant research capacity to impact on the national economy and society.

14. There is potential and support amongst stakeholders for the establishment of a National Multi-stakeholder Platform/Coalition for Plant Research in Ireland.

15. Plant research should be an integral part of any R&D strategy for functional foods in Ireland and Europe.

16. There is a need for a National Multi-stakeholder Research Initiative on Plant-Based Bioenergy in Ireland.

17. There is a need for an inter-institutional National Graduate School in Plant R & D that would effectively harness all of the dispersed expertise in plant research in Ireland in order to deliver advanced plant research training to postgraduate researchers.

18. There is strong support for plant research oriented to meeting needs in Ireland's bilateral aid partner countries (e.g. in Sub-Saharan Africa).

Appendix 1: Roles & responsibilities of respondents across different sectors surveyed

For Figures A1a-A1d the sample number of respondents is 101 (Fig. A1a), 44 (Fig A1b), 19 (Fig A1c), and 15(Fig A1d).

Fig. A1a

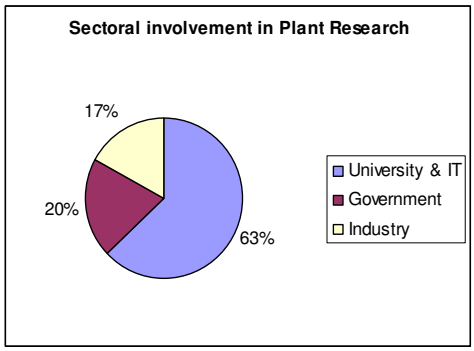


Fig. A1b

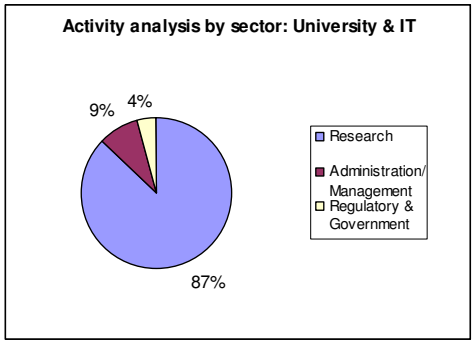


Fig. A1c

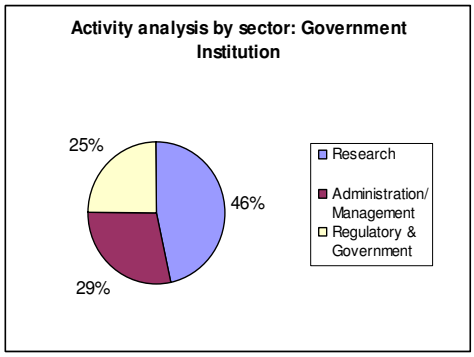
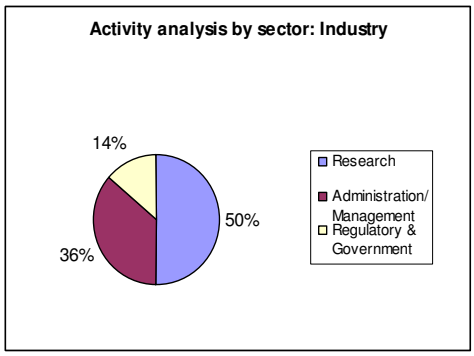
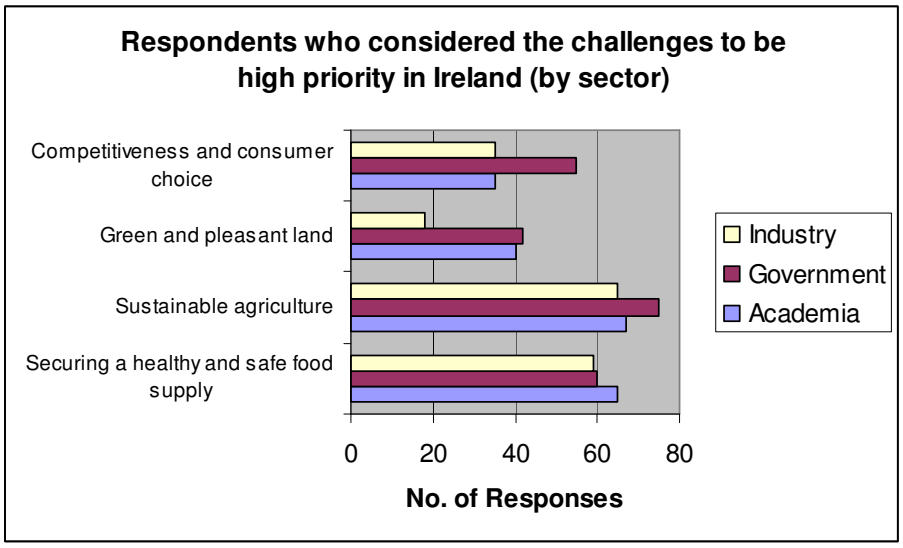
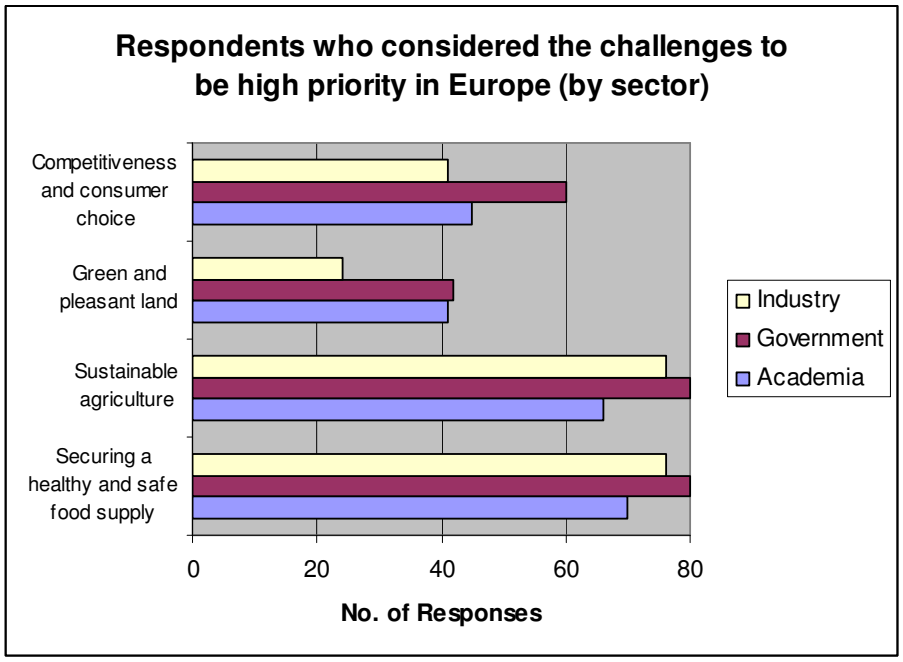


Fig. A1d



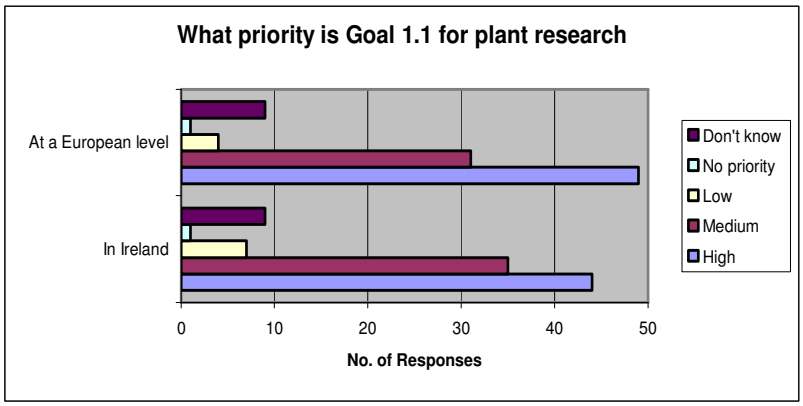
Appendix 2 (a),(b),(c): Priorities for plant research in Ireland and EU disaggregated by the sector of the respondents.





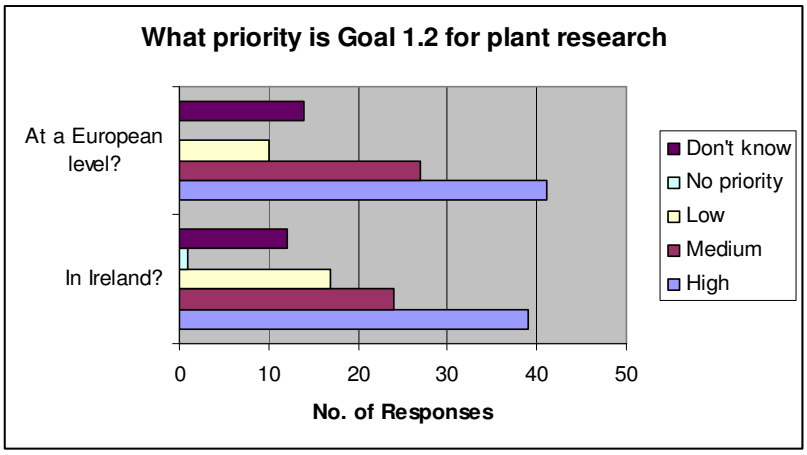
Challenges	Level of Priority	Priority in Ireland			Priority in EU		
		Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
1. Securing healthy & safe food supply	High Medium Low No priority Don't know	65% 14% 7% 2% 12%	60%	59% 29% 6% 0% 6%	70%	80% 10% 10%	76%
2. Sustainable agriculture	High Medium Low No priority Don't know	67%	75%	65% 18% 12% 0% 6%	66%	80% 20%	76%
3. Green & pleasant land	High Medium Low No priority Don't know	40%	42%	18% 53% 18% 0% 12%	41%	42% 37% 16%	24% 59%
4. Competiveness & consumer choice	High Medium Low No priority Don't know	35%	55%	35% 35% 24% 0% 6%	45%	60% 20% 10%	41% 41%

Appendix 3a & 3b: Priorities for Goal 1.1 (Develop and produce safe and high-quality food)



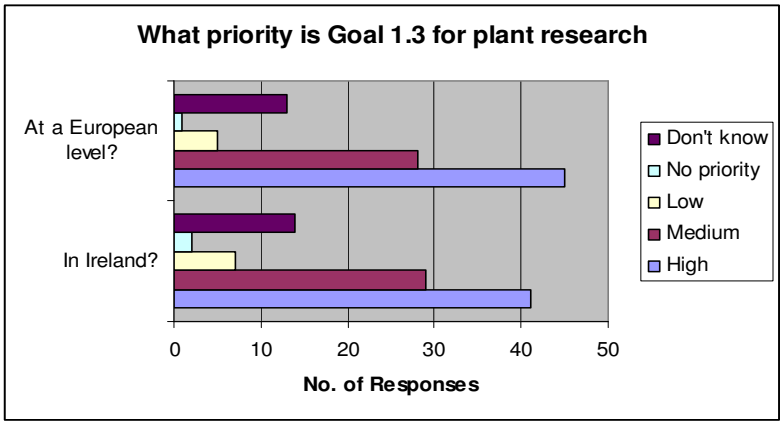
Goal 1.1	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	55%	40%	47%	58%	40%	59%
Medium	27%	30%	41%	28%	30%	29%
Low	7%	15%	6%	2%	10%	6%
No priority	2%	0%	0%	2%	0%	0%
Don't know	9%	15%	6%	9%	15%	6%

Appendix 4a & 4b: priorities for goal 1.2 (Create (functional) food products targeted at specific consumer groups and needs)



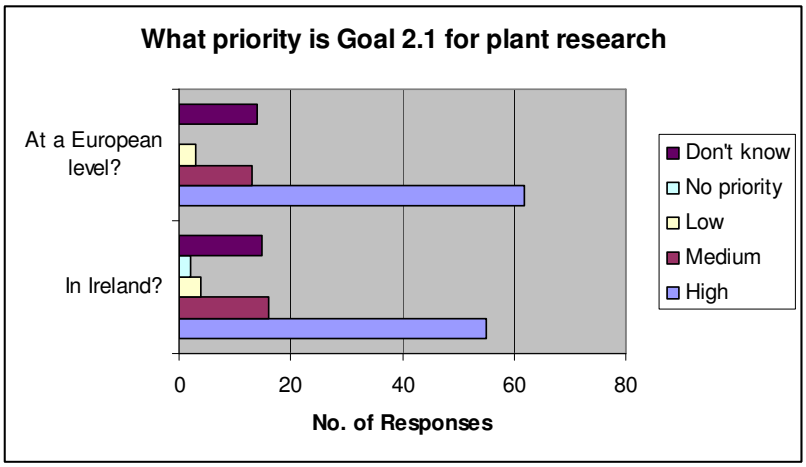
Goal 1.2	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	43%	35%	59%	45%	35%	62%
Medium	27%	25%	24%	32%	30%	19%
Low	16%	15%	12%	11%	10%	6%
No priority	2%	0%	0%	0%	0%	0%
Don't know	11%	25%	6%	11%	25%	12%

Appendix 5a & 5b: Priorities for Goal 1.3 (Produce safe, high quality, sufficient and sustainable feed)



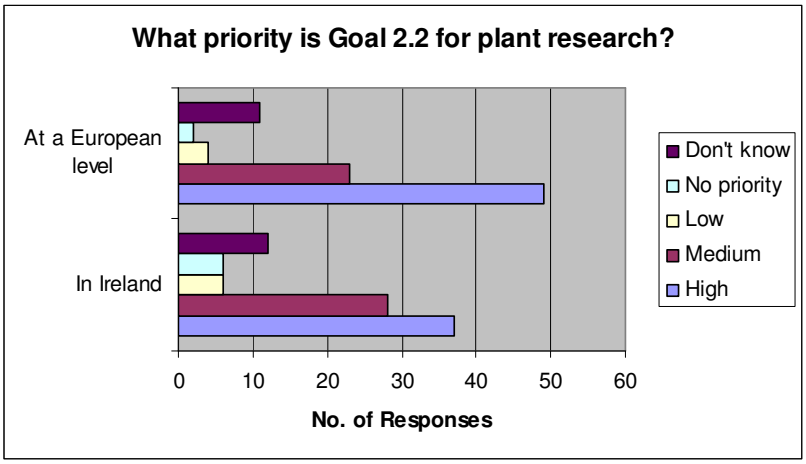
Goal 1.3	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	48%	60%	35%	52%	65%	35%
Medium	27%	10%	47%	27%	15%	41%
Low	7%	10%	6%	5%	10%	6%
No priority	2%	5%	0%	2%	0%	0%
Don't know	16%	15%	12%	14%	10%	18%

Appendix 6a & 6b: Priorities for Goal 2.1 (Improve plant productivity and quality)



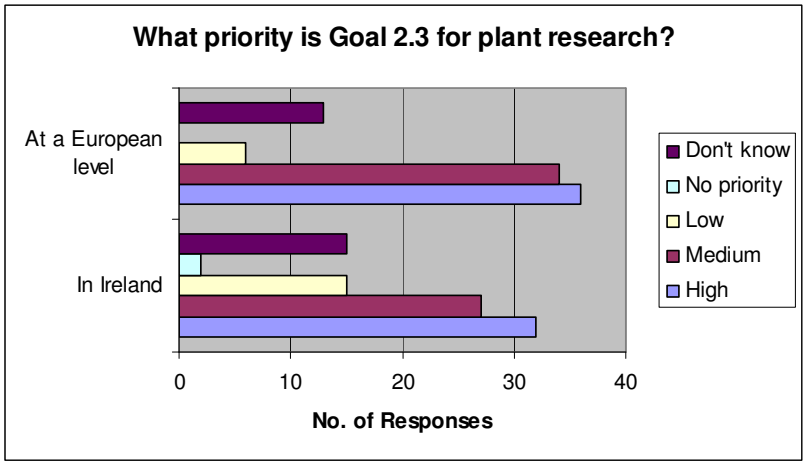
Goal 2.1	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	57%	75%	59%	64%	85%	65%
Medium	18%	5%	29%	18%	0%	24%
Low	5%	5%	0%	2%	5%	0%
No priority	2%	5%	0%	0%	0%	0%
Don't know	18%	10%	12%	16%	10%	12%

Appendix 7(a) and (b): Priorities for goal 2.2: (Reduce and optimise the environmental impact of agriculture)



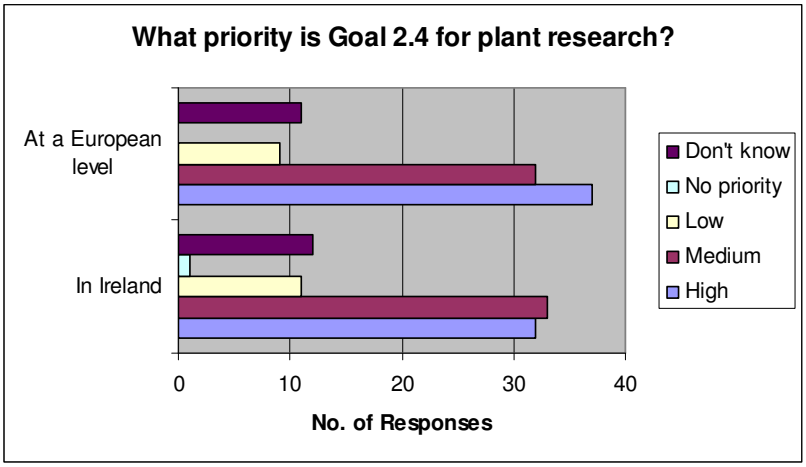
Goal 2.2	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	43%	55%	29%	52%	80%	35%
Medium	27%	25%	47%	27%	10%	41%
Low	5%	10%	6%	2%	0%	12%
No priority	7%	0%	12%	2%	0%	6%
Don't know	18%	10%	6%	16%	10%	6%

Appendix 8(a) and (b): Priorities for goal 2.3: (Boost biodiversity)



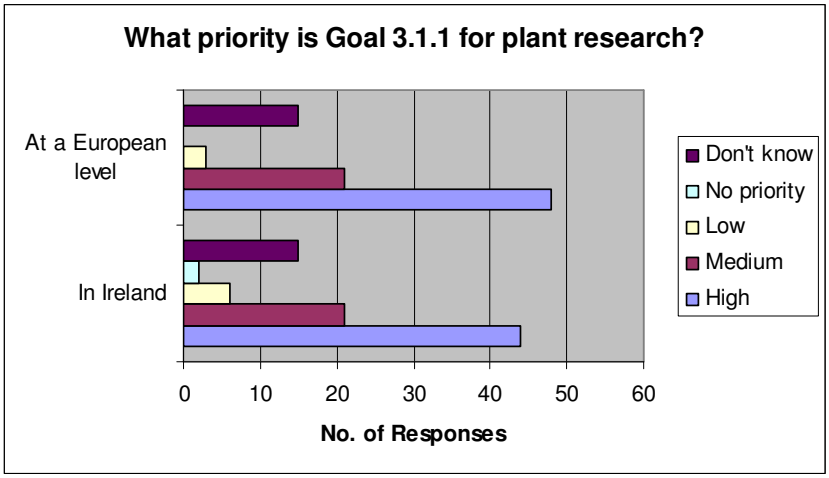
Goal 2.3	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	34%	50%	29%	33%	75%	29%
Medium	25%	25%	47%	40%	15%	53%
Low	16%	15%	18%	9%	0%	12%
No priority	2%	0%	0%	0%	0%	0%
Don't know	23%	10%	6%	19%	10%	6%

Appendix 9(a) and (b): Priorities for goal 2.4: (Enhance the aesthetical value and sustainability of the landscape)



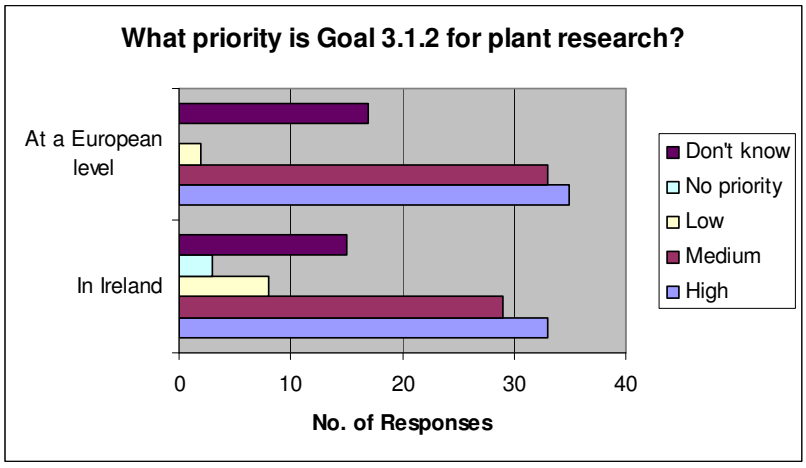
Goal 2.4	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	39%	40%	25%	43%	40%	25%
Medium	34%	30%	56%	34%	45%	50%
Low	9%	20%	12%	9%	5%	19%
No priority	2%	0%	0%	0%	0%	0%
Don't know	163%	10%	6%	14%	10%	6%

Appendix 10(a) and (b): Priorities for goal 3.1.1: (Improving the efficiency of existing industrial crops and the utility of their products)



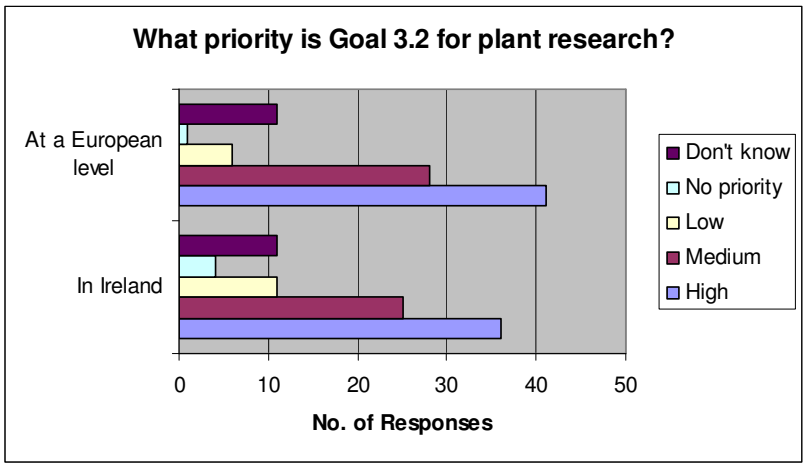
Goal 3.1.1	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	41%	58%	65%	48%	61%	65%
Medium	32%	11%	24%	27%	22%	29%
Low	7%	11%	6%	7%	0%	0%
No priority	2%	5%	0%	0%	0%	0%
Don't know	18%	16%	6%	18%	17%	6%

Appendix 11(a) and (b): Priorities for goal 3.1.2: Expanding the quality of raw materials and product range of industrial crops – new plant-based raw materials with widened utility



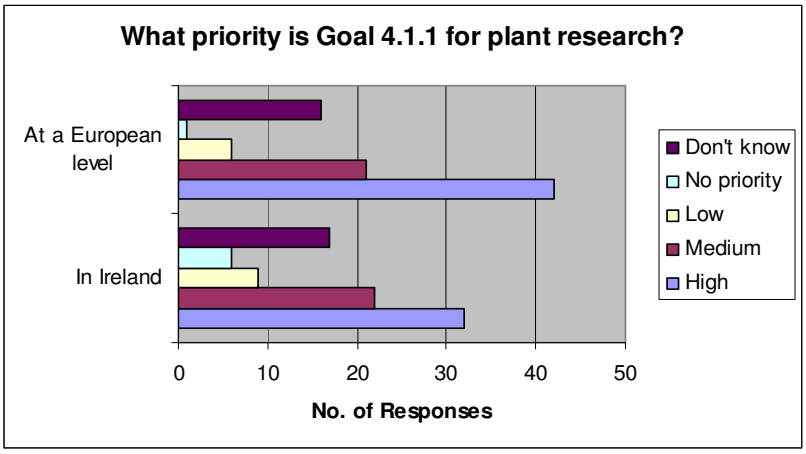
Goal 3.1.2	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	39%	32%	47%	39%	33%	53%
Medium	34%	26%	41%	39%	39%	35%
Low	5%	16%	6%	2%	6%	0%
No priority	5%	5%	0%	0%	0%	0%
Don't know	18%	21%	6%	20%	22%	12%

Appendix 12(a) and (b): Priorities for goal 3.2: Plant-based pharmaceutical and diagnostic products



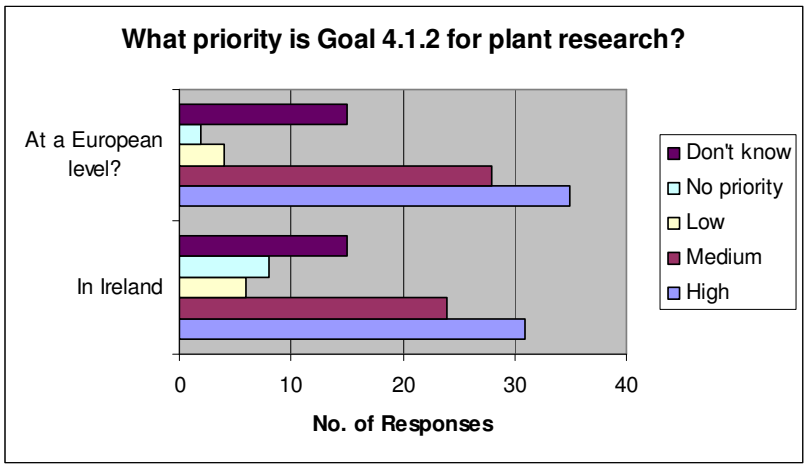
Goal 3.2	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	45%	25%	56%	48%	35%	62%
Medium	32%	30%	25%	36%	30%	25%
Low	5%	25%	12%	2%	20%	6%
No priority	5%	10%	0%	2%	0%	0%
Don't know	14%	10%	6%	11%	15%	6%

Appendix 13(a) and (b): Priorities for goal 4.1.1 Genome sequencing and biodiversity



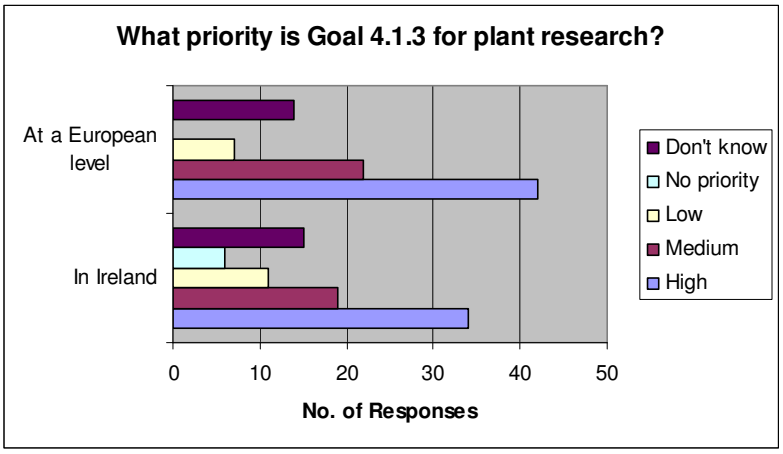
Goal 4.1.1	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	39%	25%	50%	50%	35%	50%
Medium	27%	25%	12%	25%	40%	12%
Low	7%	25%	6%	7%	5%	12%
No priority	7%	5%	12%	0%	0%	6%
Don't know	20%	20%	19%	18%	20%	19%

Appendix 14(a) and (b): Priorities for goal 4.1.2: Undertake plant systems biology



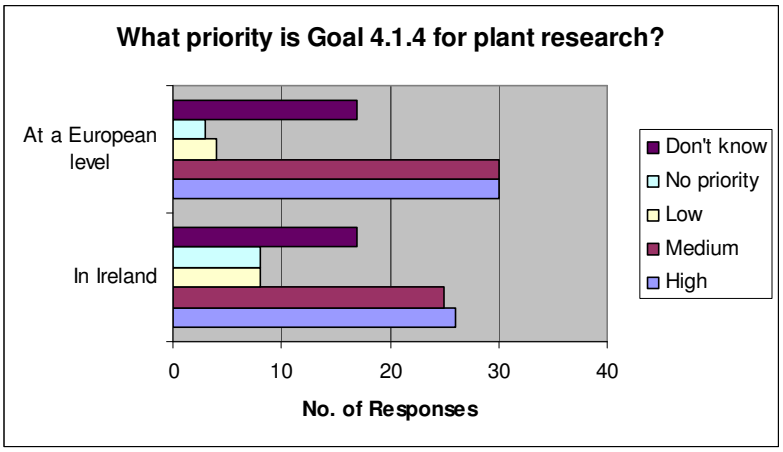
Goal 4.1.2	Priority in Ireland			Priority in EU		
	Academia	Government	Industry	Academia	Government	Industry
High	44%	30%	38%	51%	30%	38%
Medium	26%	25%	31%	28%	45%	31%
Low	5%	15%	6%	2%	10%	6%
No priority	7%	15%	6%	2%	0%	6%
Don't know	19%	15%	19%	16%	15%	19%

Appendix 15(a) and (b): Priorities for goal 4.1.3: Develop improved research tools and processes



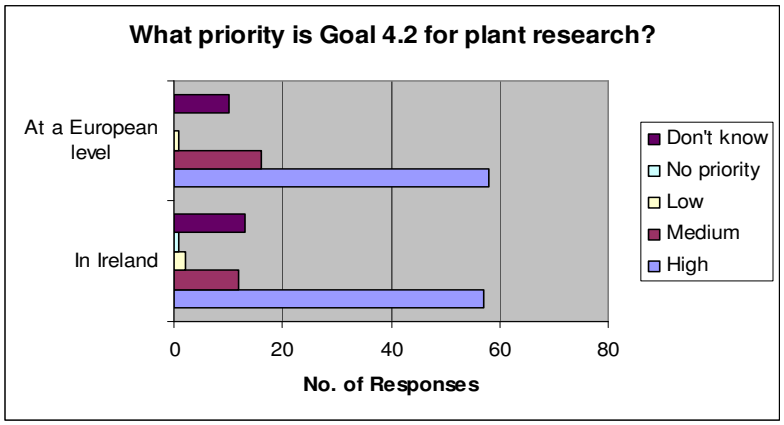
Goal 4.1.3	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	41%	45%	38%	52%	55%	44%
Medium	27%	10%	25%	30%	15%	25%
Low	7%	20%	19%	5%	15%	12%
No priority	9%	10%	0%	0%	0%	0%
Don't know	16%	15%	19%	14%	15%	19%

Appendix 16(a) and (b): Priorities for goal 4.1.4: Develop improved genetic systems for crop improvement



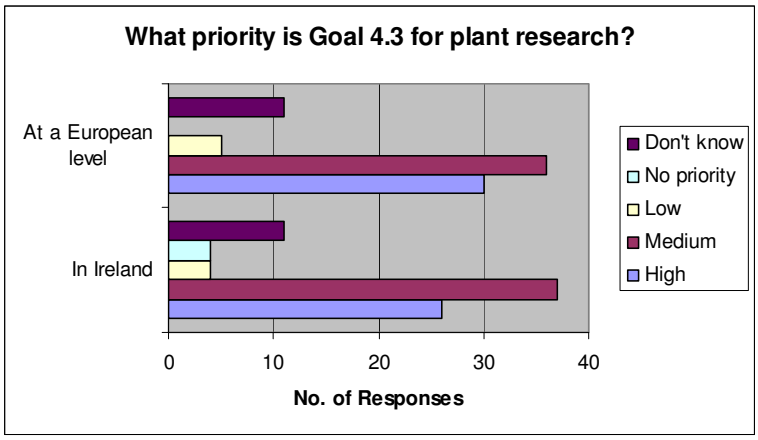
Goal 4.1.4	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	35%	20%	44%	41%	26%	44%
Medium	35%	20%	25%	36%	42%	25%
Low	0%	30%	6%	0%	11%	6%
No priority	9%	10%	12%	2%	0%	12%
Don't know	21%	20%	12%	20%	21%	12%

Appendix 17(a) and (b): Priorities for goal 4.2: Improving human resources, infrastructure and networking



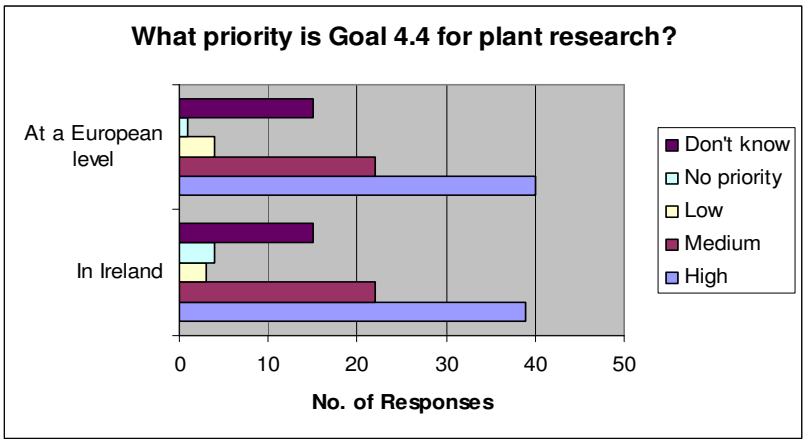
Goal 4.2	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	66%	65%	81%	68%	70%	75%
Medium	11%	20%	6%	18%	20%	12%
Low	5%	0%	0%	2%	0%	0%
No priority	0%	5%	0%	0%	0%	0%
Don't know	18%	10%	12%	11%	10%	12%

Appendix 18(a) and (b): Priorities for goal 4.3 Public and consumer involvement



Goal 4.3	Priority in Ireland			Priority in EU		
	Academia	**Government**	**Industry**	**Academia**	**Government**	**Industry**
High	40%	25%	27%	45%	30%	33%
Medium	36%	50%	53%	33%	50%	53%
Low	5%	0%	13%	7%	5%	7%
No priority	5%	10%	0%	0%	0%	0%
Don't know	14%	15%	7%	14%	15%	7%

Appendix 19 (a) and (b): Priorities for goal 4.4: Ethics, safety, legal and financial environment



Goal 4.4	Priority in Ireland			Priority in EU		
	Academia	Government	Industry	Academia	Government	Industry
High	44%	45%	60%	47%	47%	60%
Medium	23%	30%	27%	26%	26%	27%
Low	7%	0%	0%	5%	11%	0%
No priority	5%	10%	0%	2%	0%	0%
Don't know	21%	15%	13%	21%	16%	13%

Appendix 20: Stakeholders contacted in EPSO national e-consultation.

The following are the details of all of the individuals and organisations contacted for the EPSO national e-consultation that we considered to be important stakeholders in relation to the Plants for the Future Technology Platform. The e-consultation was intended to provide an important opportunity for the recipients in the following list, and their colleagues, to provide inputs on what they considered to be the main needs & priorities for plant research directions and funding in Europe, particularly from an Irish perspective. Apologies to any stakeholders that we may have missed.

Aaron Forde	Connacht Gold
AgriAware /Information	AgriAware
Aidan Cotter	Bord Bia
Aidan Forde	Saorgus Energy Ltd
Aidan Kane	Dept of Economics, NUI Galway
Aidan O Driscoll	Assistant Secretary Finance
Aisling Doyle	Plant Genetics & Biotechnology, UCC
Alain Murigneux	Biogemma
Alan Bristow	Devenish Nutrition
Alan Cassells	ZEPs, UCC
Alan Cooper	University of Ulster- Environmental sciences
Alan Dobson	Microbiology Dept, UCC
Alan Dukes	Chairman, AgriVision 2015 Committee
Alan Magee	Smurfit Institute of Genetics, TCD
Alan Matthews	TCD
Alan Matthews	Trinity College Dublin
Albert Flynn	UCC, Nutrition
ALC of Ireland /Information	Association of landscape contractors of Ireland
Alf Smiddy	Beamish & Crawford
Alison M Gallagher	University of Ulster- Biomedical Science
An Taisce /Information	An Taisce
Andre Evers	European Commission of Health & Consumer Protection
Andres Binder	Syngenta
Andrew Darcy	Galway IT
Andy Doyle	Farmers Journal
Angela Savage	NUI Galway, Carbohyate Chemistry
Angels Trius	Cybercolloids
Ania Pietrazewska	Plant Genetics & Biotechnology, UCC
Anita Hayes	Irish Seed Savers Association
Ann Lawler	Plant and Wildlife Society
Anne	Irish Wind Energy Association
Anne Heraty	Chairperson, Expert Group on Future Skills Needs (EGFSN)
Anne Marie Mullen	National Food Centre, TEAGASC Ashtown
Anne Marie Tully	National Dairy Council
Anne Morrissey	DCU Biotechnology
Anne Scott	DCU, School of Nursing
Anthony Grehan	M. Ryan Marine Sci. Inst, NUI Galway/ Nat. Biodiversity Platform
Anthony J Bjourson	University of Ulster- Biomedical Science
Aoife Brady	Botany Post grad students UCD
Aoife Clarke	IBEC Irish Business and Employers Confederation

Ashley Franks	BIOMERIT, UCC
Asim Sheikh	UCD, Division of Legal Medicine
Audrey Peggs	C&C International Ltd
Austin Duignan	Donegal Farm Relief Service
Avril Doyle	Group of the European People's Party (Christian Democrats) and European Democrats
Barbara Doyle	Zoology & Plant Science Dept, UCC
Barry Connolly	Richmond Group
Barry McSweeney	Chief Science Advisor
Barry Murphy	Horticulture centre, TEAGASC Kinsealy
Ben Ahloowalia	TEAGASC
Bernard Rice	Teagasc, Oakpark
Bernard Rooney	Kelkin
Bernie Rowe	Dewfresh Ltd.
Bill Brandon	Dept of Enterprise, Trade & Employment
Biogreen Energy Prods /Information	Biogreen Energy Prods
Bob Hanna	Chief Technical Advisor, Department of Communications, Marine and Natural Resources,
Boru Douthwaite	CIAT, Cali, Colombia
Breda Naughton	Education policy/National Biodiversity Platform
Brenda McCrystal	GreenIsle Foods, Northern Foods Group
Brendan Keane	FMC International
Brian Carney	CAMBio, Letterkenny IT
Brian Conroy	Industrial Development Agency Ireland
Brian Gillen	Natures Best
Brian Horgan	Kylemore Food Group
Brian Leahy	ADM Ireland Holdings
Brian M McKenna	UCD, Food Science
Brian McGrath	Department of Business Administration, UCD
Brian Mohally	Janssen Pharmaceutical
Brian Reidy	Keenan System
Brian Sweeney	Tech Foresight exercises
Brian Wickham	ICBF Shinagh House, Bandon, Co. Cork.
Bruce Osborne	Botany Dept, UCD
Bryan O Sullivan	Plant Genetics & Biotechnology, UCC
C Crowley	Env Manager, Irish Distillers, Dublin
Cahal MacCanna	Carbury Mushrooms Ltd.
Cal Flynn	Kerry Ingredients
Carl Ng	Botany Dept, UCD

Carly Green	UCD Bioenergy
Carmel Foley	Office of the Director of Consumer's Affairs
Carol Gibbons	Chief Science Advisor Office
Carol McGinley	Permanent Representation in Brussels
Caroline Cusack	Marine Microorganisms Research Centre
Cathal Cowan	National Food Centre (Food marketing), TEAGASC Ashtown
Catherine Barry-Ryan	Dublin Institute of Tech, School of Food Science and Environmental Health
Catherine Coxon	Dept of Geology, TCD
Catherine Halbert	Customised Food industry training
Catherine O' Mahony	Plant Genetics & Biotechnology, UCC
Catherine Staunton	TEAGASC Dairy Research, MoorePark
Catriona Boyle	Irish Veterinary Journal
CE Trust /Information	Conservation Education Trust
Cecily Kelleher	NUIG Dept of Health Promotion
Celine O Gorman	Botany Post grad students UCD
Charles Halliwell	Greencore, UK Brewing & Food
Charlie Spillane	SFI Plant Genetics & Biotechnology, UCC
Charlie Spillane	RIA Life Science committee
Chris Emblow	Ecological consultancy, Ecoserve / National Biodiversity Platform
Chris Kelly	Director, John F. Kennedy Arboretum
Christian Stafford	UCC/Enterprise Ireland
Christopher O'Grady	Director, National Parks & Wildlife Service, Dublin
Ciara Finnegan	Botany Post grad students UCD
Ciara Graham	Botany Post grad students UCD
Ciaran McCarthy	University College Hospital, Galway, Gastroenterologist
Ciaran McGowan	Cuisine de France
Ciaran Sullivan	Nestle Ireland
Ciaran Walsh	Horticulture, TEAGASC Kildalton
Claire Halpin	Division of Environmental & Applied Biology, Dundee University, Scotland
Clare Thorp	Dept of Agri, Food & Rural Dev
Cliona Hann	Botany Post grad students UCD
Colette Coughlan	Director General, RGDATA
Colette Shortt	Yakult UK
Colin Fleming	Queens, Dept of Applied Plant Science
Colin Hill	Microbiology, UCC
Colm	Botany Post grad students UCD
Colm Byrne	Country Crest Ltd

Colman O Criodain	Steering Council Member, National Biodiversity Research Platform
Colum Dunne	Glanbia Nutritionals (Europe)
Comhlamh /Information	Comhlamh Environment Group
Con Hurley	Irish Farmers' Journal
Conor Meade	Gene Flow lab, NUIM, Maynooth
Conor Ronan	ECO Wind Power
CVI /Information	Conservation Volunteers Ireland
D Hurley	Wyeth Nutritionals Ireland
Damian Allen	Assistant Principal- Policy/Forestry Planning & Dev, Johnstown Castle
Damian McDonald	Macra na Feirme
Damian O Connell	Pfizer
Dan Donnelly	Diageo Ltd
Dan Flinter	Former Chief Executive, Enterprise Ireland
Dan Milbourne	Plant Biotech Unit, TEAGASC OakPark
Daniel Browne	Dawn Meat Groups c/o paul nolan
Daniel Fulton	University of Endinburgh
Daniel Kelly	Dept of Botany, TCD
Daniela Fasi	Plant Genetics & Biotechnology, UCC
Dara Fitzgerald	BioObservation Systems
Dave McDonagh	Head of R&D, Glanbia Ingredients
Dave McNamara	EConnect Ltd
Dave O' Connor	Hibernian Windpower Ltd
David Begg	Irish Congress of Trade Unions
David Bird	Chairman of Fota Trust, Fota Arboretum
David Donoghue	Development Co-operation Directorate, Dept of Foreign Affairs
David Kidney	Balcas Ltd.
David McConnell	Genetics dept, TCD & Chair of EAGLES (research for dev countries)
David O' Beirne	UL, Dept of Biosciences
David Ryan	Head school of biology, Carlow IT
David Skerritt	Johnson Brothers
David Taylor	Sustainable Energy Ireland
David Thurnham	Irish Universities Nutrition Alliance, UCC, Ulster, TCD
Declan Connolly	Irish Seafood
Declan Farmer	Heineken Ireland
Declan Glynn	Dublin IT
Declan Hughes	Forfas
Declan Little	Woodlands/National Biodiversity Platform
Declan Troy	National Food Centre, TEAGASC, Ashtown

Declan Waugh	SWS Energy Services
Deirdre Crone	Food Industry training Unit, UCC
Deirdre Lynn	Genetic Heritage Ireland, DUCHAS
Deirdre Nic Carthaigh	HJ Heinz Frozen & Chilled Foods
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Denis Lucey	IAWS Group Plc
Derbhile Timon	RELAY Coordinating Centre, TEAGASC MoorePark
Derek Mitchell	Fungi, University College Dublin/National Biodiversity Platform
Dermot Diamond	VP Research Office DCU
Dermot Gleeson	Chair, Former Attorney General
Desmond Crofton	National Association of Regional Games Council/National Biodiversity Platform
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Diarmuid McAree	Chief Forestry Inspector, Dept. of Agricultural, Food & Rural Development
Diarmuid O Donovan	Irish Forum for Global health
Dolores Cahill	Centre for Human Proteomics
Dolores Dooley	UCC, Dept of Philosophy
Dolores O'Riordan	Dept of Food Science, UCD
Dolph Westerbos	Modus Link
Dominic Carolan	Genzyme Ireland
Don Cotton	Ecology, IT Sligo/ National Biodiversity Platform
Don Thornhill	Chairman, national Competiveness Council
Donal Creedon	Macroom Oatmeal Mills
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Dympna Furlong	Assistant Principal- Coillte Forest Research
Eamonn Pitts	Rural Economy Research Center
Earthwatch /Information	Earthwatch
Ed Walsh	Faculty of Agriculture, UCD
Eddie Hughes	Enterprise Ireland
Eddie Lowrey	Munster Proteins
Eddie Punch	ICSA, Irish Cattle and Sheep Farmers' association
Eilís Nic Dhonncha	Algae Base Centre
Eimear Cannon	DairyGold
Eimear Gallagher	National Food Centre, TEAGASC Ashtown
Eli Lilly Kinsale /Information	Eli Lilly Kinsale

Emer Colleran	NUI Galway
Emer Craven	Sustainable Energy Ireland, Glasnevin
Emma Guiney	Plant Biotech Unit, TEAGASC OakPark
Emma Reeves	Botany Post grad students UCD
Emmet Curley	Airtricity
Eucharia Meehan	HEA PRTLI
Eugene Dillon	REFIT, Renewable Energy Dept of Energy, Marine & communication
Eugene Heary	Batchelors
Eugene Hendrick	COFORD, National Council for Forest Research & Development
Eugene O Leary	Chief Executive, TECNET
Eva Clayton	GORTA
Eve Merton	BioSciences and Society (BSS) group DCU
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FAI / Information	The Fertilizer Association of Ireland
Fair Trade Ireland /Information	Fair Trade Ireland
Ferdia Marnell	Amphibians & reptiles, Duchas/ National Biodiversity Platform
Fergal Barry	Limerick IT
Fergal O Gara	Biomerit Research Centre, Microbiology Dept
Fergus Shanahan	Alimentary Pharmabiotic Centre, UCC
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Fiona Davis	Higher Education Authority PRTLI
Fiona Doohan	Dept of Environmental Resource Management, UCD
Fiona Maitland	Botanical Society of the British Isles, Ulster Museum, Belfast
Fiona Stevens	NUI Galway, Medicine, Coeliac disease
Frank Fitzsimons	Trilby Trading
Frank Murphy	Agriculture, TEAGASC Kildalton
Franklin Smyth	University of Ulster- Pharmaceutical Biotech group
G Garrell	Celtic Sea Minerals
Gabrielle	Meitheal na Gaoithe
Garret Kilroy	Hydrology, Shannon Rural Development Board/National Biodiversity Platform
Garrett Fallon	Irish Power Systems Ltd
Gary Duffy	Dept of Agriculture- Abbotstown Seed Testing
Gary Henehan	Dublin Institute of Tech, School of Food Science and Environmental Health
Gary McGann	Jefferson Smurfit

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Georg Koch	Strube-Dieckmann
George Kiely	Enterprise Ireland - sci comm
George McCarthy	Director of Research, Coillte
Georges Freyssinet	Biogemma
Ger Fitzgerald	Microbiology Dept, UCC
Ger Shortle	Organic Farm, TEAGASC Athenry
Gerard Carroll	Dundalk IT
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Gerry Doherty	Dept of Agri & Food Potato Centre, Top Farm, Raphoe, Co. Donegal
Gerry Douglas	Tree improvement research, TEAGASC Kinsealy
Gerry Doyle	Botany Dept, UCD
Gerry Gunning	Land Use, Irish Farmers' Association/National Biodiversity Platform
Giles Kingsalther	Botany Post grad students UCD
Gillian Barry	Irish Universities Promoting Science
GLDA /Information	GLDA, Garden and Landscape Designers Association
Glynn Billinghurst	Boyne Valley Foods Ltd.
Gonzalo M Dominguez	Finsa Forest products
Gordon Purvis	REPs, University College Dublin/National Biodiversity Platform
Grace Martin	Plant Genetics & Biotechnology, UCC
Grace O Donovan	Faculty of Agriculture, UCD
Graeme Dear	Skretting
Grainne O Brien	Aquaculture, BIM/National Biodiversity Platform
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Harald Seulberger	SunGene
Hassan Taweel	works on animal nutrition at Wagingen University, The Netherlands
Hazel Higgins	BIOMERIT, UCC
Helen Boles	cc: Peter Heffernan, CEO Marine Institute
Helen Dixon	Office of science and technology
Helen Walsh	EPA/ National Biodiversity Platform
Helena Lenihan	Dept of Economics, UL
Henry Lyons	Research Development Office, Tralee IT
Hilary McDonagh	SHDI - Self help Development Ireland
Hilary Tovey	Environmental Sociology, TCD/National Biodiversity Platform
Hilde Willekens	Syngenta

Hubert Fuller	Botany Dept, UCD mycotoxins
Hugh Friel	Kerry Group Plc
Ian Caffrey	Lakeland Dairies
Ian Cahill	Director, National Institute of Technology Management, Nova UCD
Ian Ireland	Donegal Cremeries
Ian Robertson	Dean of Research TCD
Ian Rowland	University of Ulster- Seaweed and Bioactive comp
Ignatius Byrne	Advisory committee on Genetic Resources for food and animals, Dept of Agriculture
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IOFGA /Information	IOFGA, Irish Organic Farmers and Growers association
Iognaid Ó Muircheartaigh	Universities Ireland
IPCC/Information	Irish Peatland Conservation Council
Ireland Markets'/ Information	Ireland Markets'
Irish Meterological Office /Information	Irish Meterological Office (agri division)
Irish Peatland Conservation Council	Peatland Ecosystems/National Biodiversity Platform
Irish Society for Information Technology in Agriculture/ Information	The Irish Society for Information Technology in Agriculture
IW Trust/Information	Irish Wildlife Trust
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Jack Kelly	Energy Action
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James Henry	Odlum group
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Jim Cooper	Queens, Dept of Applied Plant Science
Jim Cusack	Shackleton Milling Ltd.
Jim Flanagan	TEAGASC
Jim G Crowley	Organic Tillage, TEAGASC OakPark
Jim Gibbons	Germinal Seeds
Jim McNeill	Kellog Company of Ireland

Jim Morrissey	Irish Seaweed Centre
Jim O Mahony	Biofuels, TEAGASC
Jim Provan	Evolutionary Genetics, Queens University Belfast
Jim Ryan	CIRCA group, R&D Consultancy
Jim Shorten	Wyeth Nutritionals Ireland
Jimmy Tolan	Fyffes
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Joe Crockett	Carlow County Council
Joe Flynn	Timber Marketing Services
Joe Harford	Yamanouchi Ireland
Joe Keeling	Keelings
Joe O Sullivan	Drinagh Co-op
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John Barry	Yves Rocher
John Bartlett	Head of Research, Sligo IT
John Boylan	Boylan's Fruit
John Brosnan	Tree Council of Ireland
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John Donnelly	Tayto, Ireland
John Dunphy	Power Seeds Ltd
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John Fitzgerald	Irish Potato Federation
John Flahavan	Flahavans
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John Gillespie	Assistant Secretary Personnel-Corporate Affairs
John Gilroy	College Proteins Ltd
John Holland	Economics and Planning Division, DAF
John Horgan	Kepak Group
John Hourican	Bord na Mona
John Lynch	Bord na Mona Energy Ltd
John Moloney	Group Managing Director, Glanbia
John O Reilly	Davy Stockbrokers
John Parnell	TCD Botanic Gardens
John Sheridan	IFA National Potato Committee
John Slater	CAMBio, Letterkenny IT
John Toomey	Rye Valley Foods
John Tyrell	Irish cooperative organisation society Ltd (ICOS)
John Wilson	Steering Committee of NBPR, Duchas/National Biodiversity Platform
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Karen O Neill	Danone Ltd
Karl Leavy	ESB Customer Supply
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Kevin Whelan	Arch Chemicals
Kieran Hynes	Glenpatrick Spring Water
Kieran Mack	Botany Post grad students UCD
Klaus K. Nielsen	DLF Trifolium
Larry O' Loughlin	Irish Aid Advisory Committee, outgoing
Laura Cassidy	Ward Industries Group, pet food
Laura Mahoney	Royal Irish Academy
Leonora Bishop	BioConnect Ireland
Leonora Bishop	IDA
Leslie Dowley	Teagasc, Oakpark
Liam Dolan	Cell & Developmental Biology Department, John Innes Centre
Liam Donnelly	Director, Food Research, TEAGASC
Liam Downey	Ex Teagasc
Liam Larkin	Goulding chemicals
Liam Lysaght	Heritage Council/National Biodiversity Platform
Liam McCumiskey (deceased)	Environmental Protection Agency FW:Tom McLoughlin
Liam O Rourke	Chivers Ireland
Liam Staunton	Horticulture centre, TEAGASC Kinsealy
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Liz O Brien	Alimentary Health Ltd

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Mairead McGuinness	European Parliament
Mairtin Mac Siurtain	Crop Science; Horticulture and Forestry
Mairtin Walsh	Irish Sea Fisheries Board
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Marian Harkin	MEP- biofuels
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Martin Hayes	Vita Cortex
Martin Hynes	Embark Initiative
Martin Lyes	Enterprise Ireland, Director
Martin Murphy	R&R Hall
Martin Ryan	Irish Sugar, Director of Agri-Business
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Mary Cullinan	Dept of Agriculture
Mary Finan	Managing director, Wilson Hartnell PR
Mary Gillick	Enterprise Ireland
Mary Kelly	SFI
Mary Kelly	Director General, EPA
Mary Mulvihill	Science Writer
Mary O Connell	Plant Genetics & Biotechnology, UCC
Mary Sutton	Advisory Board for Development Coordination Ireland
Mary Walsh	Cork Corporation
Matt Dempsey	Irish Farmers' Journal
Matt Moran	Irish BioIndustry Association
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Matthew Jebb	Vascular Plants, Duchas/National Biodiversity Platform
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Michael Burke	Chanelle group
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Michael Delaney	Research Development Office, Cork Institute of technology
Michael Diffley	Gweedore Foods
Michael Doran	Rural Generation Ltd.
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Michael McGrath	Sanofi Aventis
Michael Parkinson	DCU Biotechnology
Michael Prendergast	Kilkenny Cereals
Michael Treacy	Permanent Representation in Brussels
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Michéal ó Cinnéide	Marine Institute
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Miroslav Griga	Agritech Plant Research Ltd
Mitchel Barry	Allied Foods
Morina O'Neill	Comhlámh
N O Connell	Scotia Pharmaceuticals, UK
National Environmental Education Centre /Information	National Environmental Education Centre
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Neil O Carroll	Conoco Phillips, Co Cork
Neil Ruane	Aquaculture, ERI, UCC
Neil Stronach	Director, Fota Wildlife Park
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Noel Corcoran	Carbery Group
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Noel O Flynn	Orieachtas Committee on Agri (bioenergy)
Noel Sexton	Cybercolors
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Paddy Harrington	IFA national Grains committee
Paddy Higgins	Pat the Baker
Paddy Rogan	Chief Veterinary Officer
Paddy Whelan	Whelan Frozen Foods
Padraic Cribben	Johnston Mooney & O'Brien
Padraig Hennessy	Dept of Enterprise, Trade & Employment
Padraig Murphy	BioSciences and Society (BSS) group
Padraig O'Conaill	Responsible for research, EU FP7
Pat Caulfield	Nutricia Infant Nutrition
Pat Cummins	Connacht Gold
Pat Delaney	Small Firms Association
Pat Mulhern	Athlone IT
Pat Mulvihill	Castlemahon Food Products
Pat Neville	Forest ecology, Coillte/ National Biodiversity Platform
Pat O Mahony	Food Safety Authority of Ireland
Pat O Reilly	Monsanto
Pat O Rourke	ICMSA, Irish Cremeries Association
Pat Wall	Former Chief Executive, FSAI
Patricia Comiskey	Fisheries policy, BIM/ National Biodiversity Platform
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Patricia Kiernan	UCD, Dublin Molecular Medicine Centre
Patricia Mulcahy	Carlow IT
Patricia O Hara	Western Development Commission
Patrick Burke	Cambrex Cork
Patrick Cunningham	Genetics dept, TCD
Patrick Cunningham	TCD, Dept of Genetics
Patrick Flanagan	Ex. Environmental Protection Agency
Patrick Hannon, Rev	St Patrick's College, Maynooth
Patrick Milne	Milne Food Ltd.
Patrick Murray	Murray Timber Products
Paul Devane	AGI Therapeutics Ltd
Paul Dunne	Assistant Principal- Financial Management/Projects
Paul Farrell	Aertech Ltd
Paul Giller	Freshwater Ecology, University College Cork/National Biodiversity Platform
Paul Kelly	FAPRI-Ireland partnership: Economic projections for Irish agriculture
Paul MacCarten	Cybercolloids
Paul Martin	Irish Food Processors
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Peter Hunt	Comex McKinnon
Peter Kennedy, Ruth Davis	VP Research Office UCC
Peter McKenna	Rotunda Hospital
Peter Mitchell	University of Ulster- Seaweed and Bioactive comp
Peter Philpot	Campbell Soup Ireland
Peter Sandys	Seroba Bio Ventures
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Philip O Reilly	Assistant Secretary Finance, Direct payments
Philippe Savinel	Irish Distillers Group
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Power Seeds /Information	Power Seeds
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R Keane	Quintiles
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Raymond Winters	Grove Farms
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Richard O Brien	Southern Milling
Richard Weyl	Biodiversity, Dept of Environment NI/National Biodiversity Platform
Rindert Peerbolte	Crop Design
Robert Perryman	Irish Bio-Ventures
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Roger Downer	UL, Dept of Chemical and Environmental Science
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Ronan Loftus	Identigen
Ronan Power	Alltech, director of research europe
Ronnie Wilson	Monaghan mushrooms
Rosaleen Devery	DCU, National Committee for Nutritional sciences
Rosemary Garth	IBEC Irish Business and Employers Confederation
Ross Campbell	Margiot Ltd
Ross Campbell	Cybercolloids
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Ruaidhri Neavyn	Carlow IT
Ruth Barrington	Health Research Board
Ruth Carmody	Department of Ed., Policy, Research and Science
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Sarah Ryan	Botany Post grad students UCD
Sarah Ryan	Philip Farrelly & partners, Agri consultancy
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Seamus Healy	Assistant Secretary Animal Health, Disease Erradication
Sean Brady	Irish Sugar, Greencore
Sean Hearn	Glanbia Agribusiness-Gain Feeds
Sean Molloy	Price Waterhouse Coopers
Seán Strain	UU School of Biomedical Sciences
Sean Tuohy	MoorePark Technology Ltd
Shane Colgan	EPA
Shaun Connor	Abbott Ireland
Sidney Rowell	Alcan Packaging
Sile Doran	Info at Food and inks Industry Ireland
Simon Barber	EuropaBio
Simon Berrow	Cetaceans, Shannon Dolphin and Wildlife Foundation/National Biodiversity Platform
Simon Browne	Kraft Foods Ireland
Siobhan	Conference of Heads of Irish Universities
Siobhan O Sullivan	Irish Council for Bioethics
Siobhán O' Sullivan	Scientific Director
Stefan Krane	NUI Galway, Seaweed
Stephanie Cunningham	Irish Pride Bakeries
Stephanie O Neill	STI Awareness Programme
Stephen Finnegan	Fyffes - Cork
Stephen McClean	University of Ulster- Pharmaceutical Biotech group
Stephen	Bird watch Ireland/ National

Newton	Biodiversity Platform
Steve Cowman	Chief Executive, Greenstar
Steve Hughes	ESRC centre for genomics in society
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Steve Miller	Proctor & Gamble
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Tim Conlon	IRCHSS FP6
Tim Dullea	Tipperary Co-op creamery
Tim Lennon	Drummonds Seeds
Tim McKenna	Irish Dairy Board
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Tom Boylan	Prof of economics, NUI Galway
Tom Burton	Irish Bioenergy association
Tom Doyle	IT Blancherstown
Tom Farrell	Shannonside Milk Products
Tom McCabe	IVAX Ireland
Tom McLoughlin	Chairperson, GM advisory committee, EPA
Tom Noonan	Kerry Bio Science
Tom Noonan	Maxol
Tom O Neill	Pfizer Cork
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Tom Teehan	Chief Agricultural Inspector
Tommy Gallagher	Botany Dept, UCD
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Tony Barry	Barrys Tea
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Wendy Guiry	Algae Base Centre
William C Harris	SFI
William Grainger	Grainger Sawmills
Willie Donnelly	Head of Research and Innovation, Waterford IT
Win-Chin Chiang	Mead Johnson Nutritional
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