The Future of Crop Production in Ireland: Climate Change and Sustainable Land Use

Dr. Fiona Doohan

UCD School of Biology & Environmental Science

5th June 2009

Earth Systems Institute
University College Dublin

Email: esi.admin@ucd.ie

Institiúid na gCóras Domhanda
An Coláiste Ollscoile Baile Átha Cliath

Web: www.ucd.ie/earth

Outline

- Crop production on plant Earth today
- Crop production in Ireland today
- Climate Change & Sustainable land use
- Threats and opportunities

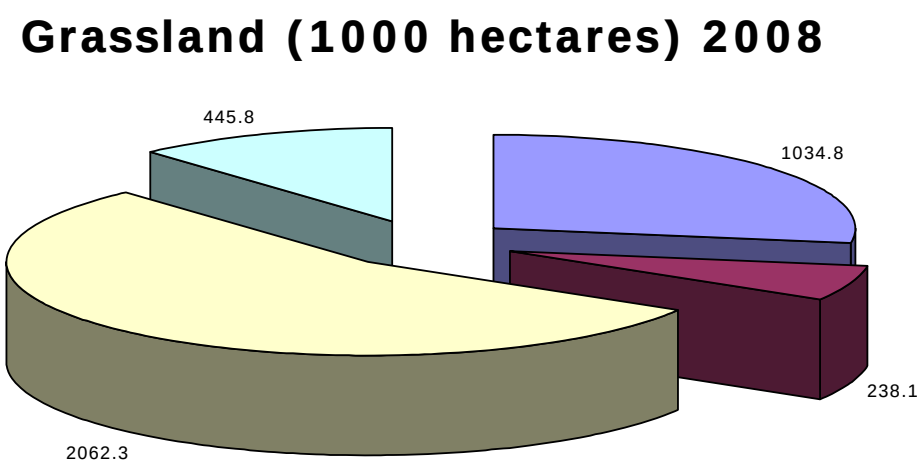
Crop production on plant Earth today

Flickr: Aaron Escobar

- 14 billion hectares ice-free land
- 10% used for crop production, 25% for pasture
- 2 billion tonne grain produced annually – 10% is traded internationally
- 40% of cereals are irrigated (75% of freshwater consumed annually)

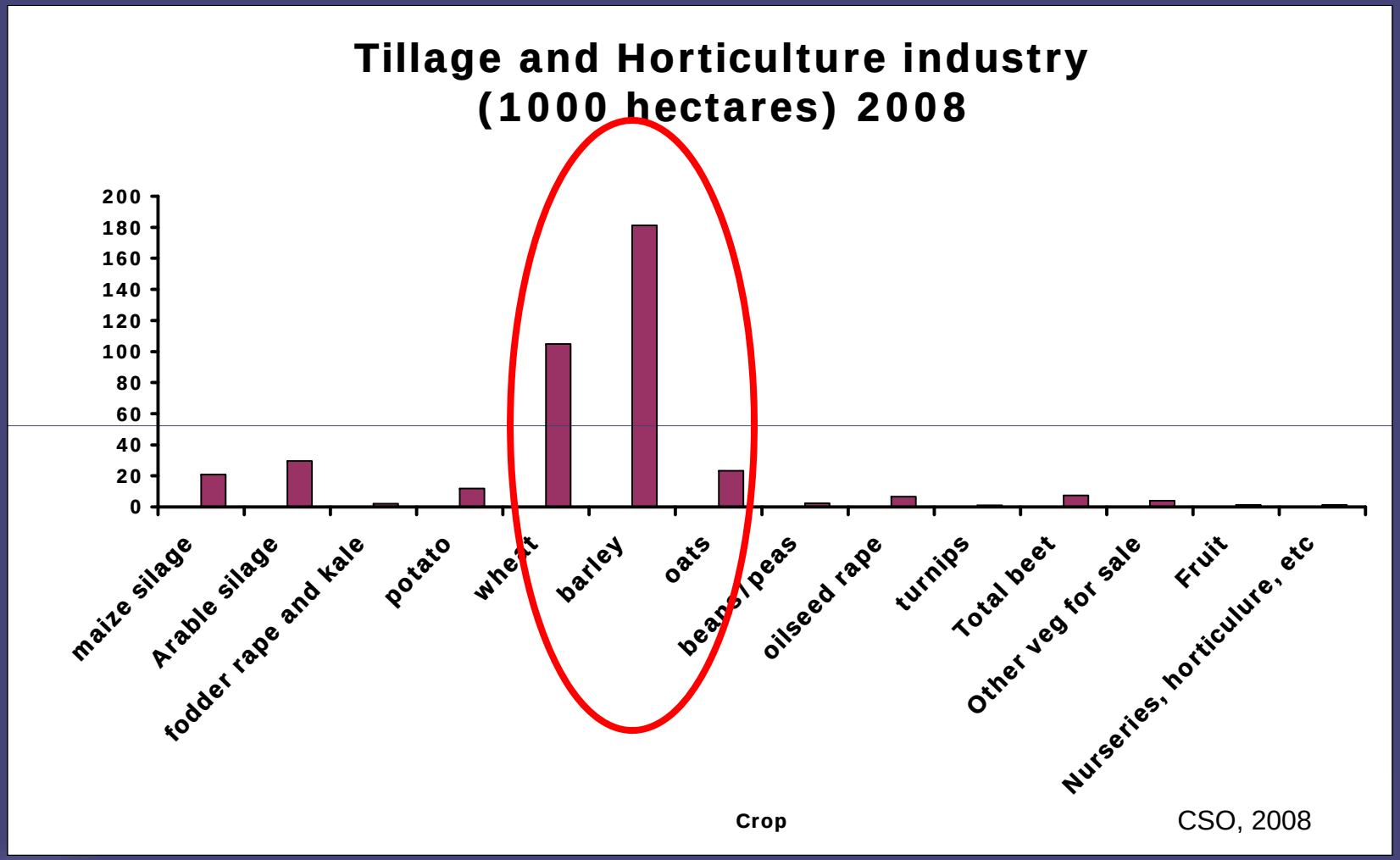
Crop production in Ireland today

Dominated by grassland (90% agricultural area)



Grassland (1000 hectares) 2008

After: CSO, 2008


Tillage and Horticulture industry
(1000 hectares) 2008
200
180
160
140
120
100
80
60
40
20
0
maize silage
Arable silage
fodder rape and kale
potato
wheat
barley
oats
beans/peas
oilseed rape
turnips
Total beet
Other veg for sale
Fruit
Nurseries, horticulure, etc
Crop
CSO, 2008

What drives Irish Crop production?

- **Animal production**
  - Grasses & Cereals - feed, bedding etc.
- **Food industry**
  - E.g. oats, potato, etc.
- **Energy Industry**
  - Biofuels
- **Policy**
  - Single Payments Scheme
  - EU Renewable Energy Directive

http://www.ucd.ie/studyatucd/featureddegree/dairybusiness/index.html

The Future of Crop Production in Ireland

- *Climate Change*
- *Sustainable Land Use*

Sustainable land use - Crop production

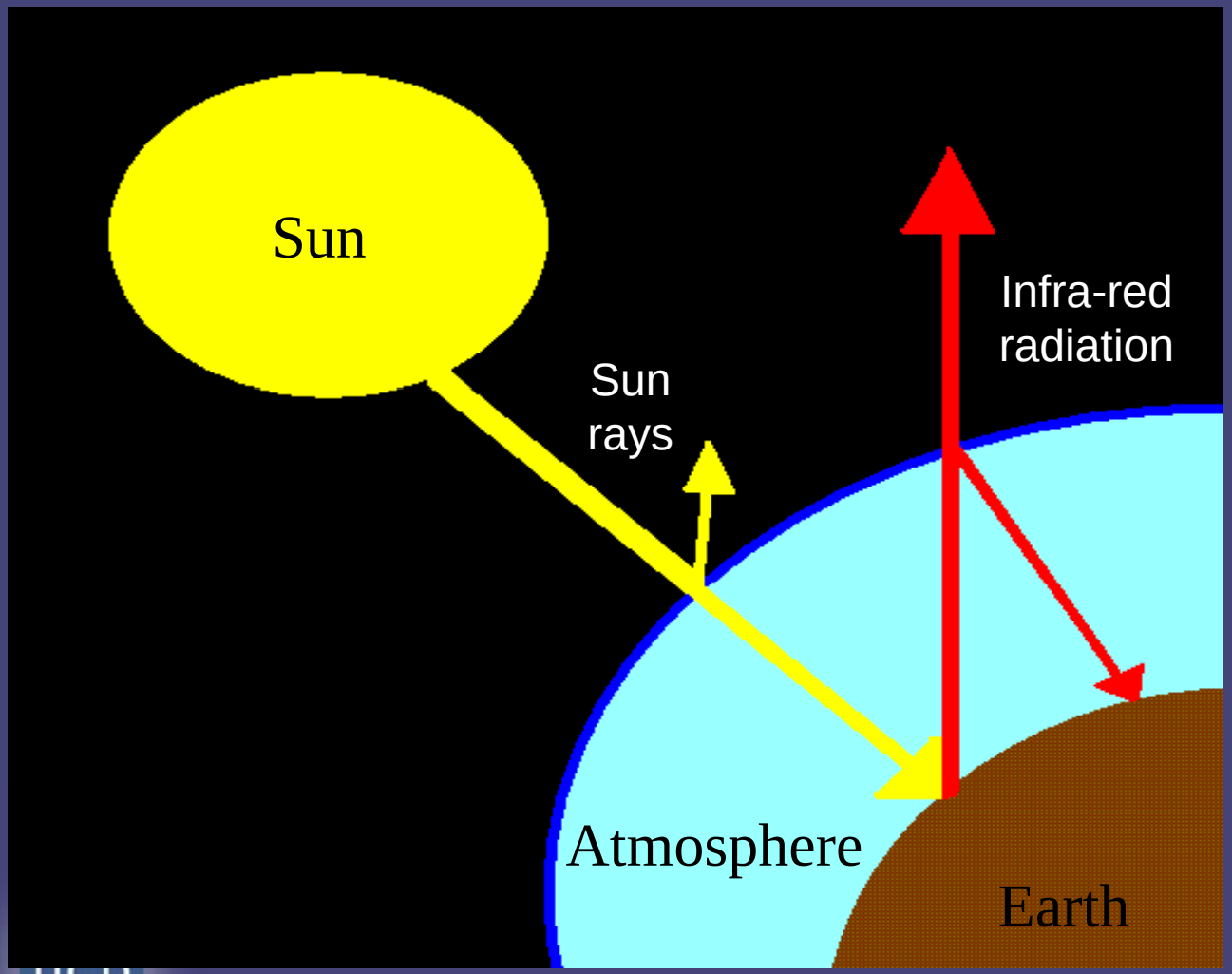
Management of human use of land such that the integrity and functioning of its natural process and components is not impaired (De Groot, 1994)

Bottom line: want our environment to be clean, healthy and productive

Balancing short-term human needs with the capacity of the land to provide crops in the longer term

- Manage
  - Nutrient application
  - Irrigation
  - Diseases and pests
- Protect biodiversity
- Maintain multifunctionality
- Rural Environmental Protection Scheme

Climate change

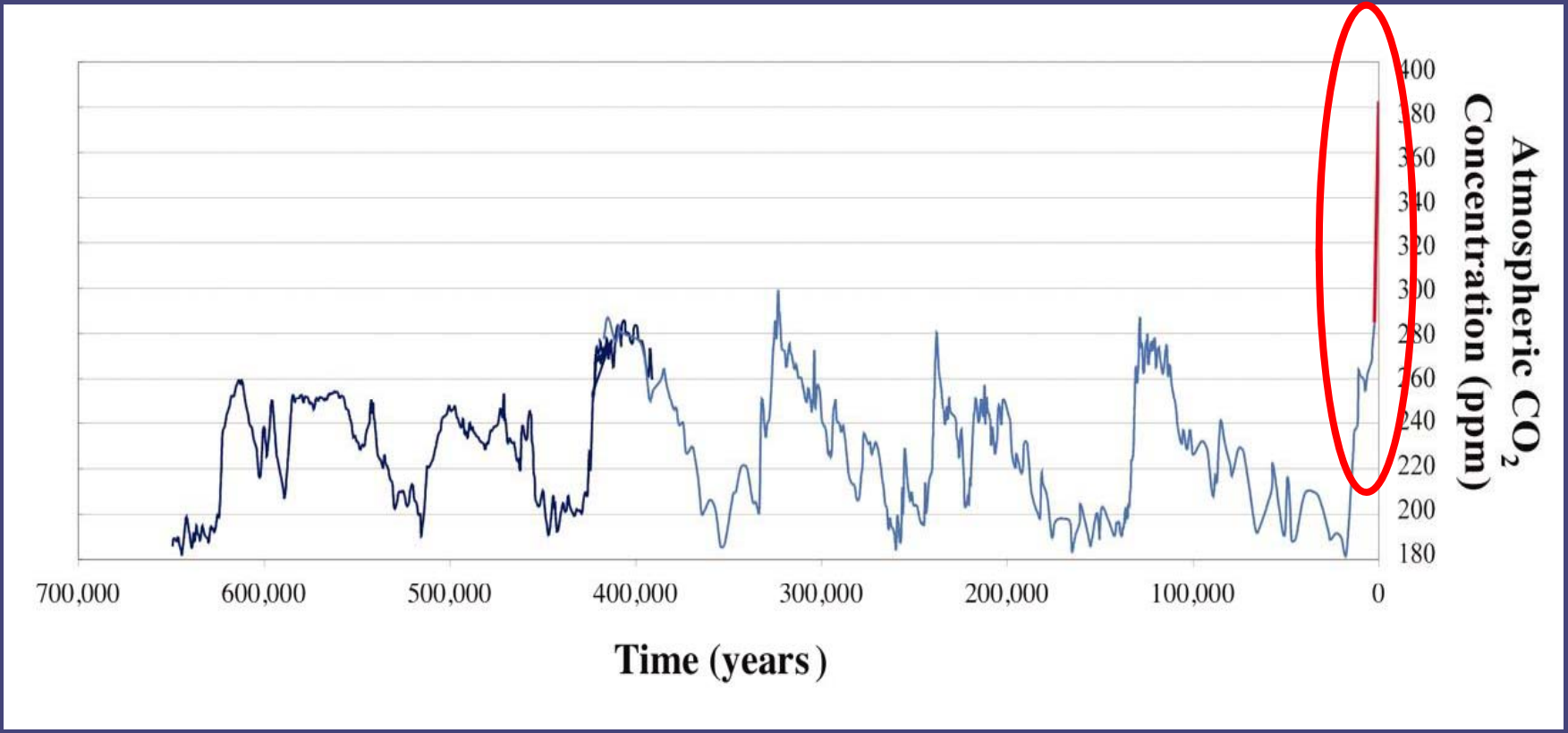


Greenhouse gases

- Carbon dioxide
- Methane
- Nitrous oxide
- Water vapour

Increase in Greenhouse Gases (GHG) = global warming

Climate Change

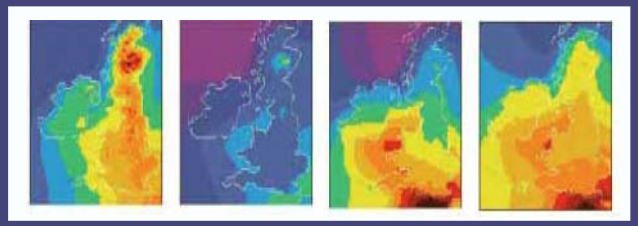


Global CO_2 concentration over time

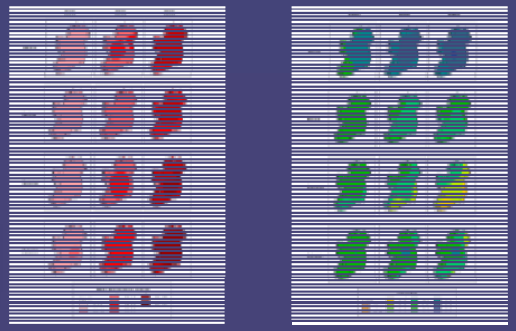
Elements; 3:171-178 (2007)

Climate Change in Ireland

Ireland in a Warmer World - Scientific Predictions of the Irish Climate in the Twenty-First Century
(2001-CD-C4-M2)
STRIVE Report
Dunne *et al.* (2009)
Mét Eireann/UCD



CLIMATE CHANGE –
Refining the Impacts for Ireland
(2001-CD-C3-M1)
STRIVE Report
Sweeney *et al.* (2008)
NUI Maynooth/UCD/TCD



Temperature

From 2 – 4 degree increases by the end of the century

Hotter in SW

Hotter in summer/autumn

Precipitation:

Dryer summers (up to 18%), wetter winters (up to 25%)

Climate change and sustainable land use present challenges and opportunities for crop production in Ireland

- Crop selection
- Crop fertilization
- Disease & Disease control
- New products from crops

Crop Selection

- A biogeographical issue
  - Challenge: e.g. potato, willow, pasture
  - Opportunity:
    - potato, cereals, new crops (e.g. maize, soybean, maybe even sunflower in specific regions!)
    - Bioenergy crops e.g. maize

Crop fertilization

- Challenge:
  - reducing inputs/costs
  - Maintaining biodiversity & ecosystem functionality –REPS
- Opportunity
  - ‘Smart’ fertilisers
  - Biofertilisation

Biofertilisation

Use of microoorganisms to promote plant growth

- Plant growth-promoting bacteria
  - Highly variable results to date in the field....

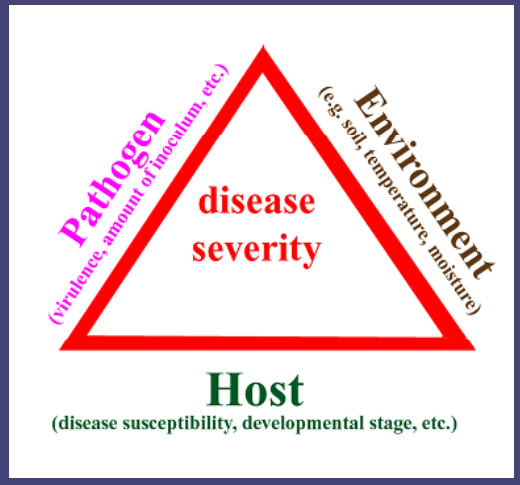
Effect of bacteria on wheat biomass under field conditions

	Increase in shoot weight[a]	Increase in grain yield[a]
Bacterium A	17.8*	3.6
Bacterium B	21.5*	5.8
Bacterium C	15.9*	-5.8
Bacterium D	16.8*	6.7

[a]Relative to control wheat plants, not treated with any bacterium.

- Biological nitrogen fixation
  - No effective bacteria known for cereals

Disease & Disease control



Disease Control

- Cultural practices
- Fungicides
- Plant resistance
- Biological control

UCD DUBLIN

Disease & Disease control

- Challenges
  - Climate change: shift in pest/pathogen populations
  - Sustainable land use:
    - lack of effective disease control measures
    - New EU legislation
- Opportunities
  - Develop disease-/pest-resistant crops
  - Develop new disease control measures
  - Reduced requirement for control of some diseases

Challenges

EU legislation – ban on certain fungicides

Fungal infection. Septoria kills tissue on wheat leaves, hindering the plant's growth.

AGRICULTURE

European Pesticide Rules Promote Resistance, Researchers Warn

Despite intense opposition from farmer groups and scientists, the European Parliament voted last week to approve new regulations that could ultimately outlaw up to one-quarter of the pesticides on the European market. The legislation mandates a new licensing strategy inspired by the so-called precautionary principle, which calls for substances to be considered potentially harmful until proven safe for human health and the environment.

Concerned that pesticides would be immediately banned, farmers had warned of devastated crop yields: "EU pesticides ban will 'wipe out' carrot crop," declared one British newspaper. Although not endorsing such dire forecasts, some agricultural scientists opposed the regulations for other reasons: They say that any reduction in available pesticides will accelerate the development of plant pests' and pathogens' resistance to the remaining agents. They also question the scientific grounding of the hazard criterion.

"The portfolio [of pesticides] that we have is already compromised in some cases by resistance," says John Lucas of the U.K. agricultural institute Rothamsted Research in Harpenden, a vocal opponent of the new licensing rules. He and his colleagues fear that pesticide resistance could become as problematic as the multiresistant bacteria strains causing havoc in hospitals.

Over the years, agricultural scientists have fought a cat-and-mouse game with insects and plant pathogens, developing new substances as the pests become more resistant to the older ones. Because novel pesticides can take a decade or more to develop, the scientists are concerned that they won't be able to keep up, as permits for existing ones expire and aren't renewed. Some worry especially about losing the azoles, a group of compounds used to manage plant diseases, including septoria leaf blotch, caused by the fungus *Mycosphaerella graminicola*. The most important wheat crop disease in northwestern Europe, septoria was originally controlled by several types of fungicides. But since the 1980s, *M. graminicola* has developed widespread resistance to two pesticide classes, leaving the azoles as the last line of defense.

The rules approved by the European Parliament on 13 January were watered down compared with the first proposal, which would have outlawed about 85% of pesticides currently in use, according to an assessment by the U.K. Pesticide Safety Directorate (PSD). The approved regulations could still lead to the ban of 14% to 23% of pesticides, the PSD estimates.

According to the European Parliament, the new legislation will be applied gradually, with "no sudden or large-scale withdrawal of products from the market," and there should "be ample time for farmers to adapt by using alternatives or non-chemical methods, or for the pesticides industry to devise replacements." The rules also include 5-year permit exceptions for substances deemed hazardous but needed to control serious dangers to plant health, including the development of resistance.

The 5-year rule will "give us some breathing space," says Lucas, who is nevertheless skeptical about its implementation. Time for research is also essential for developing an alternative to pesticide usage: disease-resistant crops. James Brown, who researches ways to make wheat varieties both septoria-resistant and high-yielding at the John Innes Centre in Norwich, U.K., says, "This is a gradual process." He warns that "diseases don't stay the same." For instance, breeding barley that resists ramularia, a disease that emerged in 1998, "will take at least 10 years." In the meantime, he says, "fungicides are necessary to back up varieties' resistance" to disease.

The pesticide regulations' dependence on the precautionary principle riles many. "This hazard-assessment argument is really where the big problem lies," says Lucas. "As scientists, we find it very worrying that things go through that don't really stack up in terms of scientific evidence."

Alan Boobis, who studies toxic mechanisms of drugs and environmental chemicals at Imperial College London, agrees. "I feel that action is being taken on the basis of a policy position that doesn't reflect the state of the science," Boobis says, arguing that pesticides are one of the most thoroughly evaluated types of products on the market.

Last month, Lucas delivered to a member of the European Parliament a petition he and 71 other European scientists signed against the ruling. "We would be the first to say that we are not encouraging a solely chemical approach to the control of disease," notes Lucas. But he wonders if even common toothpaste would be approved if everyday life were governed by the same precautionary principle now applied to pesticides.

Emma Hockridge, a campaigner for the Soil Association, which supports the new rules, says she recognizes that narrowing down pesticide diversity can lead to increased resistance of certain pests. "But this highlights the fact that any agricultural system which is heavily reliant on pesticides for crop management is inherently unsustainable in the long term," says Hockridge, adding that natural management methods promote healthier and more robust crops.

For Mark Whalon, director of the Pesticides Alternatives Laboratory at Michigan State University in East Lansing, the issue has implications beyond European boundaries. In an age of globalization, if unwanted pest resistance arises in Europe, it will likely make its way to the United States, Whalon says. An organic farmer, Whalon understands the calls for a greener and safer environment. But as editor of the Arthropods Resistant to Pesticides Database, he also takes the resistance issue very seriously. He notes that eliminating pesticides primarily based on human health concerns could leave farmers with ones that are more dangerous to the ecosystems around crops. "Just because it is safer for humans doesn't make a pesticide safer for the environment," he warns.

-SARA COELHO

CREDIT: LATTA CHAMBERLAIN/JOHN INNES CENTRE

Concern about emerging pathogen resistance to remaining chemicals

Septoria tritici blotch disease of wheat

Reduced sensitivity to chemicals available for control (Teagasc, 2009)

UCD-Teagasc collaboration:

1. Investigating natural host resistance to this disease

2. Biological control of this disease

Challenges

Climate change – e.g. Fusarium head blight disease of cereals

- Affects small grain cereals
- Some types of the pathogen can also attack maize and miscanthus
- Causes yield loss
- Mycotoxin contamination of grain
  - Major problem for cereal production - EU legislation dictates max. permissible levels

Challenges

Climate change – e.g. Fusarium head blight disease of cereals

Home
Weather
Buy & Sell
Jobs
Property
Harvest Highlights
Opinion (Blogs)
Forums & Photos
Videos
Prices & Trends
FW Academy
Events
Rural Living
Online Dating
Shop
Business
Special Reports
Email Newsletters
About This Site

News

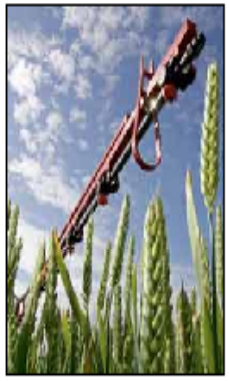
Tuesday 2 June, 2009

You are in: Home > Arable

Email Newsletters

Browse news by type:

All | Livestock | Arable | Dairy | Poultry | Machinery | Business | Local



Mycotoxins: Keeping the grain trade on track

15/05/2009 05:13:00

Crops

Mycotoxins look like being an annual issue. Lucy de la Pasture finds out how the grain train coped last year and what it means for growers this season.

The Miller's Tale

Challenging, that's how Martin Savage, Trade Policy Manager for the National Association of British and Irish Millers (NABIM), describes their experience of grain from the 2008 harvest.

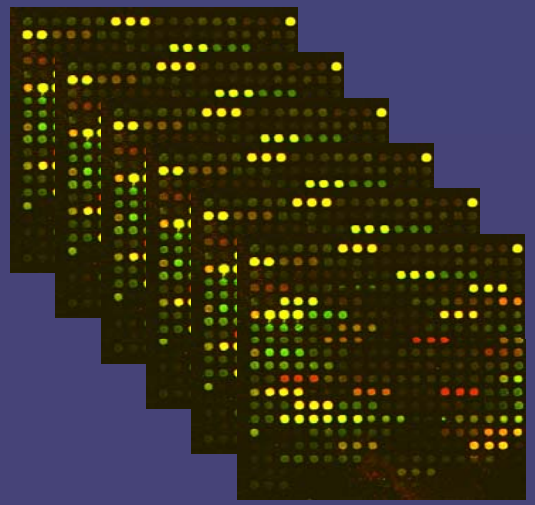
Alarm bells rang early in the season as sample results from mills arrived at NABIM. These showed about 10% of samples were exceeding deoxynivalenol (DON) limits (compared with 7% in 2007). But the real cause for concern was that background levels were high, indicating mycotoxins were present in most samples, though not exceeding limits.

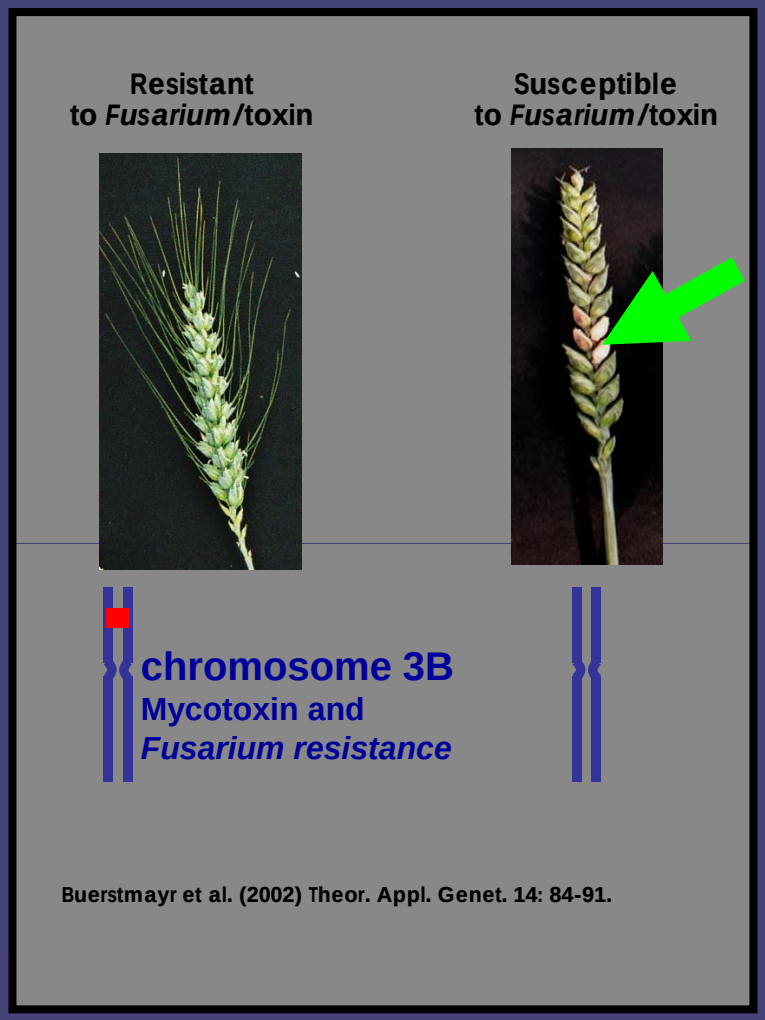
"The harvesting period was long and protracted because of the wet conditions." says Mr Savage. "This gave us problems with DON and zearalenone (ZON),

Opportunities:

Develop disease-/pest-resistant crops

- Identify genes
- Breed/transfer more copies/alternative copies into plants





Buerstmayr et al. (2002) Theor. Appl. Genet. 14: 84-91.

Functional genomics to identify genes that confer resistance to *Fusarium* (and mycotoxin)

Walter et al. (2008) Functional and Integrative Genomics

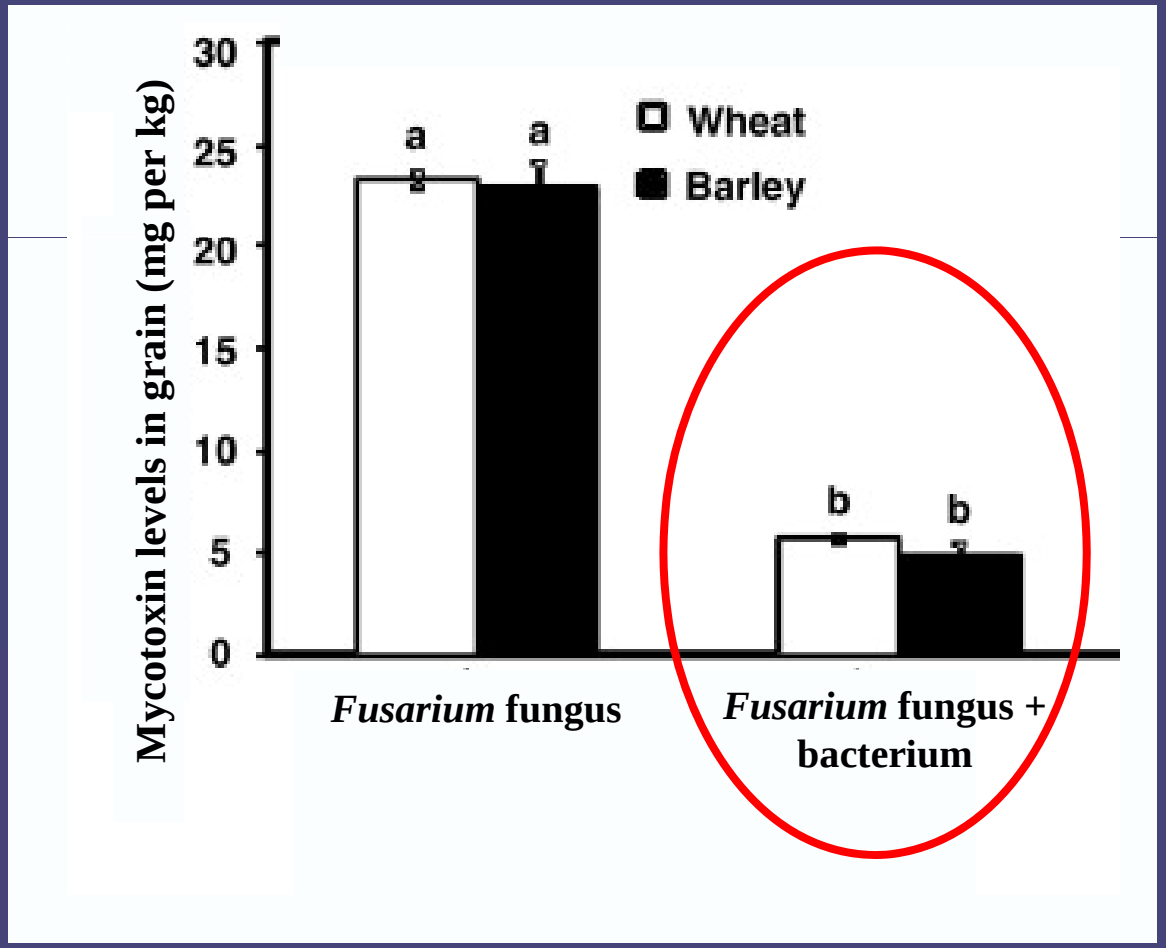
Opportunities:

Develop new disease control measures – UCD / UCC project

Fusarium disease

Fusarium disease development inhibited by application of a bacterium

Reduced mycotoxin contamination in grain from *Fusarium*-infected cereals – field trials



New products from crops

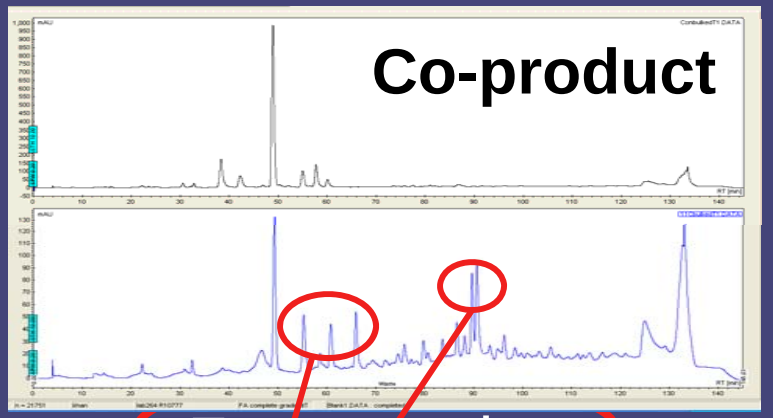
- Examples
  - Pharming
    - Production of therapeutic vaccines in plant cell cultures/GM plants (contained conditions)
    - Extraction of novel nutraceuticals from crops
  - Co-production of biofuel and other value-added products from plant residue

Ethanol and high value products from wheat straw – UCD/Teagasc project

Fungi

Hydrolysis

Fermentation



Fermentation

Distillation

Valuable by-products

Cellulosic ethanol

Genetically modified crops

- Threats
  - Horizontal gene flow
  - Biodiversity
  - Superweeds
  - Benefits
    - Food security
    - Food safety
- Questions?
  - 1. What is the benefit?
  - 2. Who benefits?
  - 3. Is it rigourously tested?

Is this GM wheat?

- **A wheat gene into wheat**
- **Selectable marker = wheat gene**
- **Vector = wheat DNA**

Summary

- Crops – underpin Irish agriculture
- Climate change: must test the models
- Sustainable land use: multifunctionality
  - must have a clear national priority re cropping systems and research priorities
    - crop breeding for Irish systems must be a priority at national level
  - must not repeat the green revolution – work at ecosystem level where possible and inform policy

Crop Science UCD: present and future perspectives

Crop stress biology, crop adaptation and crop
















Summary

- We cannot rely on imports in the long term – must be innovative & work together
- GM – ethical, in addition to economic, responsibility to consider this technology
- Plant biotechnology – an untapped industry in Ireland
  - Policy must support the development of this industry

Acknowledgements

- Teagasc
- UCD
  - Molecular Plant-Microbe Interactions Group
  - UCD Plant Science collaborators
- International collaborators (Purdue, Rothamsted Research, BOKU University Vienna, John Innes Centre)
- Funding agencies:

sfi science foundation ireland fondúireacht eolaíochta éireann

NDP

UCD DUBLIN

Enterprise Ireland

NDP PLEAN FORBARTHA NÁISIÚNTA

Dept. of Agriculture, Food and Rural Development

EU

UCD Earth Systems Institute

Meeting the Challenge of Climate Change Seminar Series

In collaboration with

Comhar Sustainable Development Council, Environmental Protection Agency, Forfás, Geological Survey of Ireland, Marine Institute, Met Éireann, Sustainable Energy Ireland & Teagasc

Further details on the seminar series is available at www.ucd.ie/earth

A paper and podcast of this seminar will be available on the ESI website soon, please join the online ESI mailing list for such notifications

ESI email: esi.admin@ucd.ie

UCD Earth Systems Institute

Meeting the Challenge of Climate Change Seminar Series

Next week...Seminar #23...the final seminar in the series

Friday 12th June 2009

Royal College of Physicians of Ireland, 12.30pm

Dr. Iseult Lynch

UCD School of Chemistry & Chemical Biology

The nano-environment: nanotechnology applications and impact on the environment

Further details available at www.ucd.ie/earth