Innovations for Sustainable Agriculture

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Topics

- Drivers for changes in agricultural practice
- Challenges facing farmers
- Achieving sustainability
- Sustainable innovation for tomorrow’s growers

Demand for food is driven by population growth and rising calorie consumption

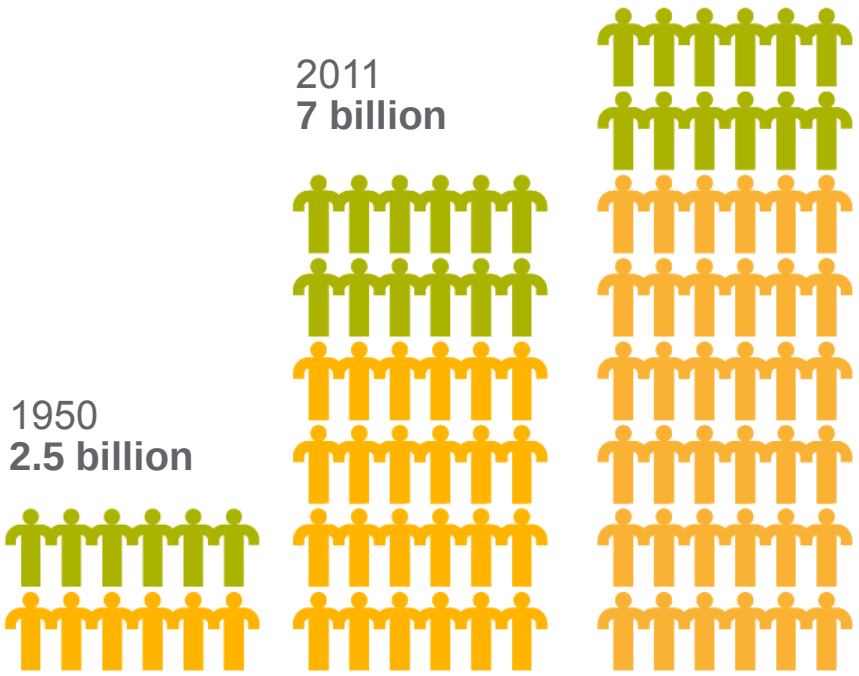
World population
> 80% of growth happens in emerging markets

Developed
Emerging

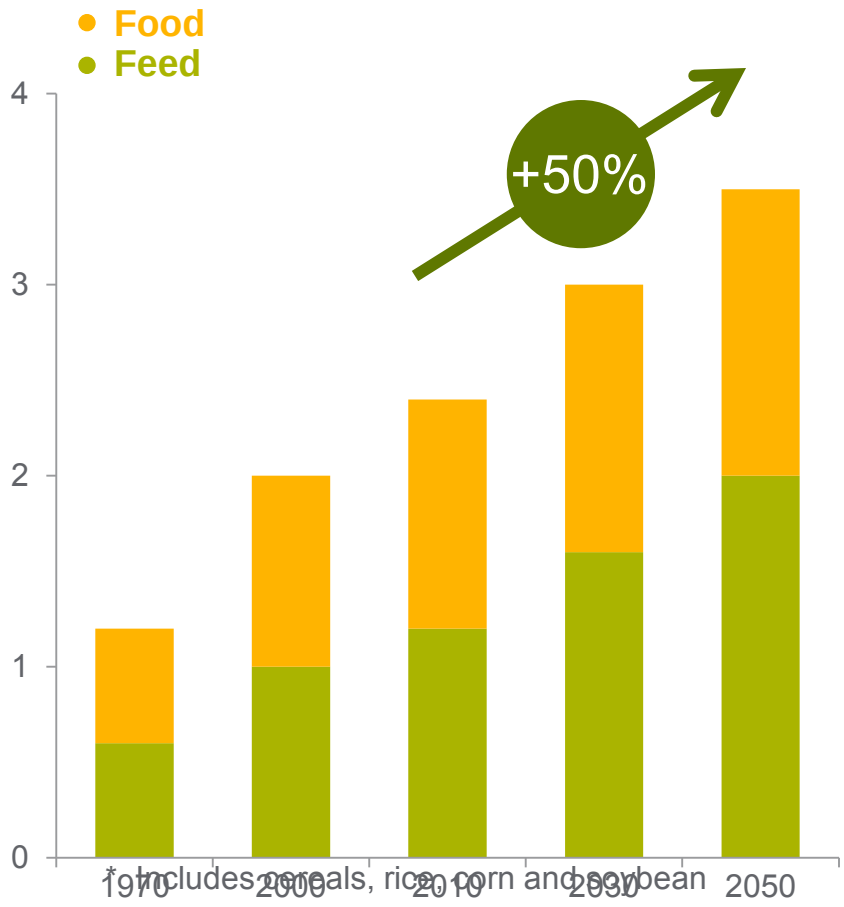
1950
2.5 billion

2011
7 billion

2050
9 billion



World demand for major crops*
bn tonnes



* Includes cereals, rice, corn and soybean

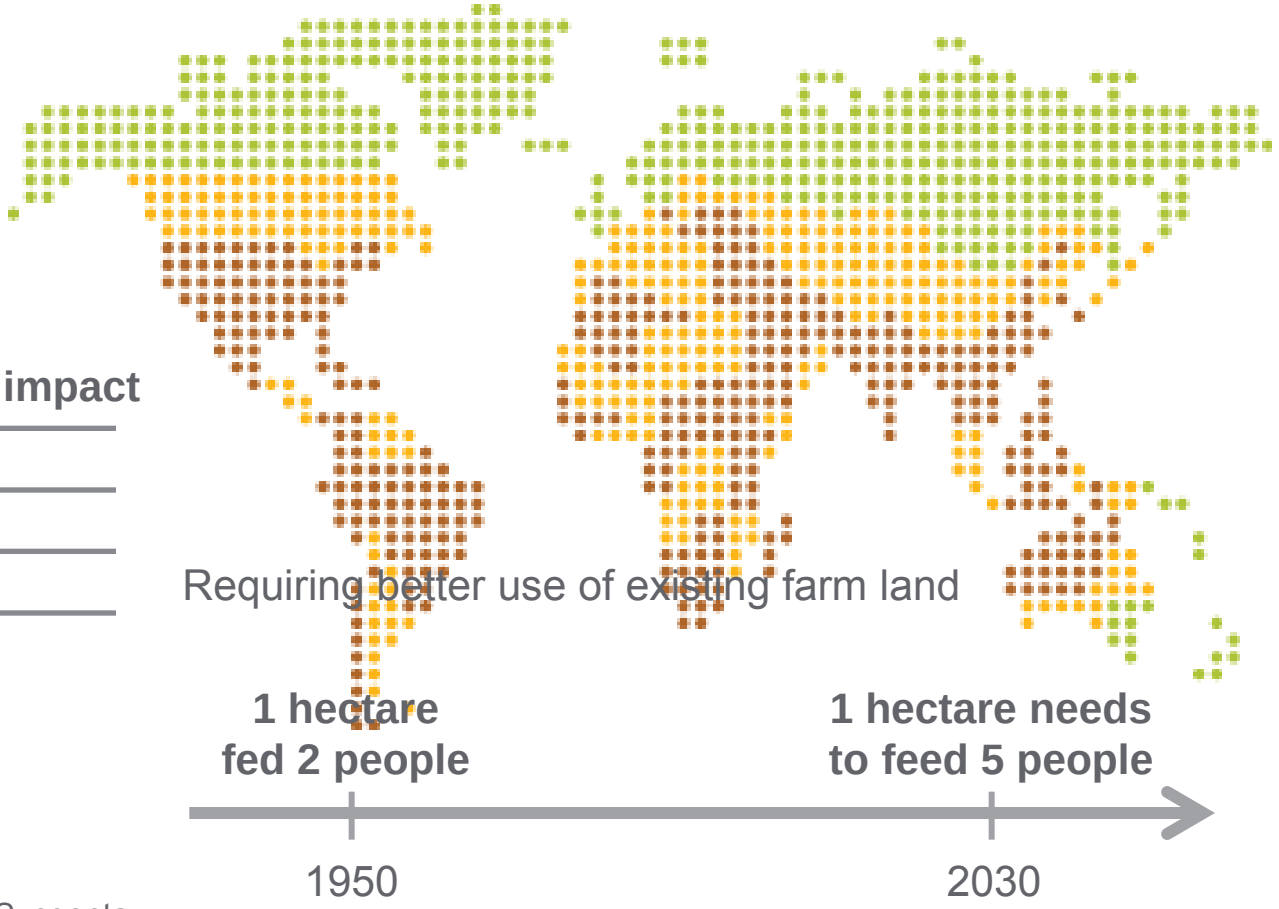
Source: FAO, Syngenta analysis

Climate Change is NOT Far off in the Future

- Global mean temp has already risen by 0.8^{o}C since 1880's
- Further rise 1-5^{o}C is inevitable
- Geographically a 2^{o}C warming will be very unevenly distributed (Robin Clark, Met Office, at IAgrM Nov2012)
- Most recent estimates of CC Futures are INCREASINGLY PESSIMISTIC
- "Statistically there is no doubt that (weather) volatility is going to increase." (Charles Godfray at IAgrM Nov2012)
- Severe, damaging weather events will become much more common (GFP "UK Food Supply Chain Resilience subgroup 2012")
- 2012 was not a one in 100 year event for UK farmers!

Environmental stresses are increasing

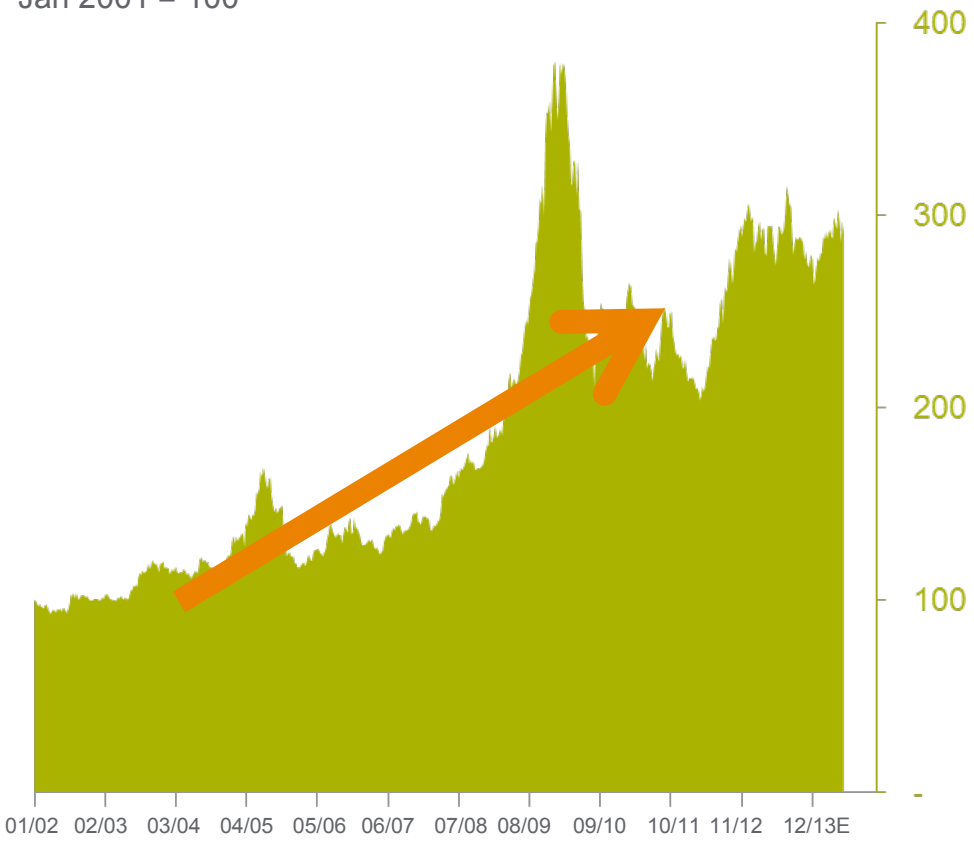
World stress map
The change in climate is already reducing water and arable land



Source: UNEP, Cline, Syngenta

Increasing crop price volatility

Crop price index**
Jan 2001 = 100



Long term: crop prices rising

Heightened government intervention

Ongoing demand growth: emerging markets

Challenging supply/ demand balance

*STU ratio for combined corn, soy, wheat and rice per USDA defined marketing season

**Equally weighted basket of corn (C1 Cmdty), soybeans (S 1 Cmdty), rice (Thai 100% Grade B, fob Bangkok), wheat (W 1 Cmdty). Prices in $/bu and $/cwt converted to $/ton. Prices: last update 12.07.12. As of March 2011 Index uses Thai rice rather than CBOT.

Source: WASDE July 2012 for STU, Bloomberg for prices, Syngenta analysis

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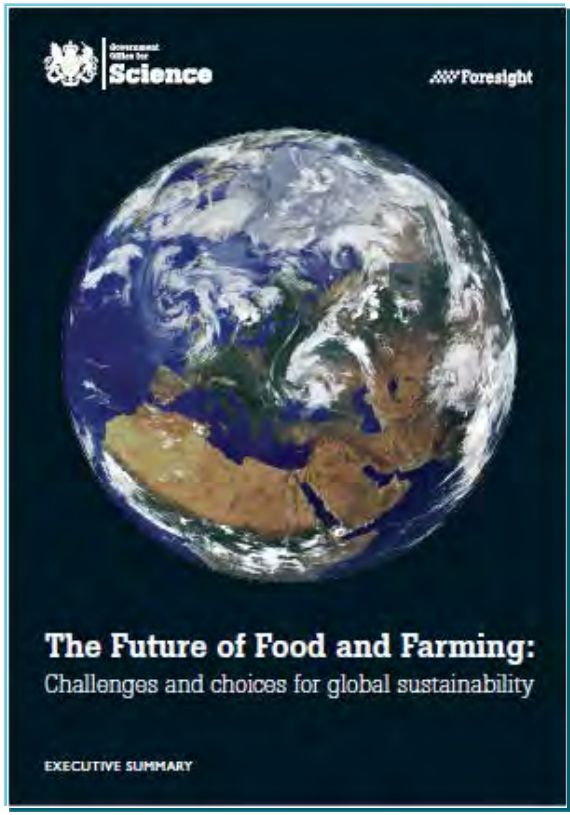
Recommendations in the UK's Global Food and Farming Futures report aim to address these challenges

- Investing in **new knowledge**.
- Promoting **sustainable intensification**.
- Anticipating major issues with **water availability** .
- Improving the **evidence base** upon which decisions are made and develop **metrics** to assess progress.
- Making **sustainable** food production central in development.
- Including the **environment** in food system economics.
- Working on the assumption that there is **little new land** for agriculture.

…….. a huge undertaking



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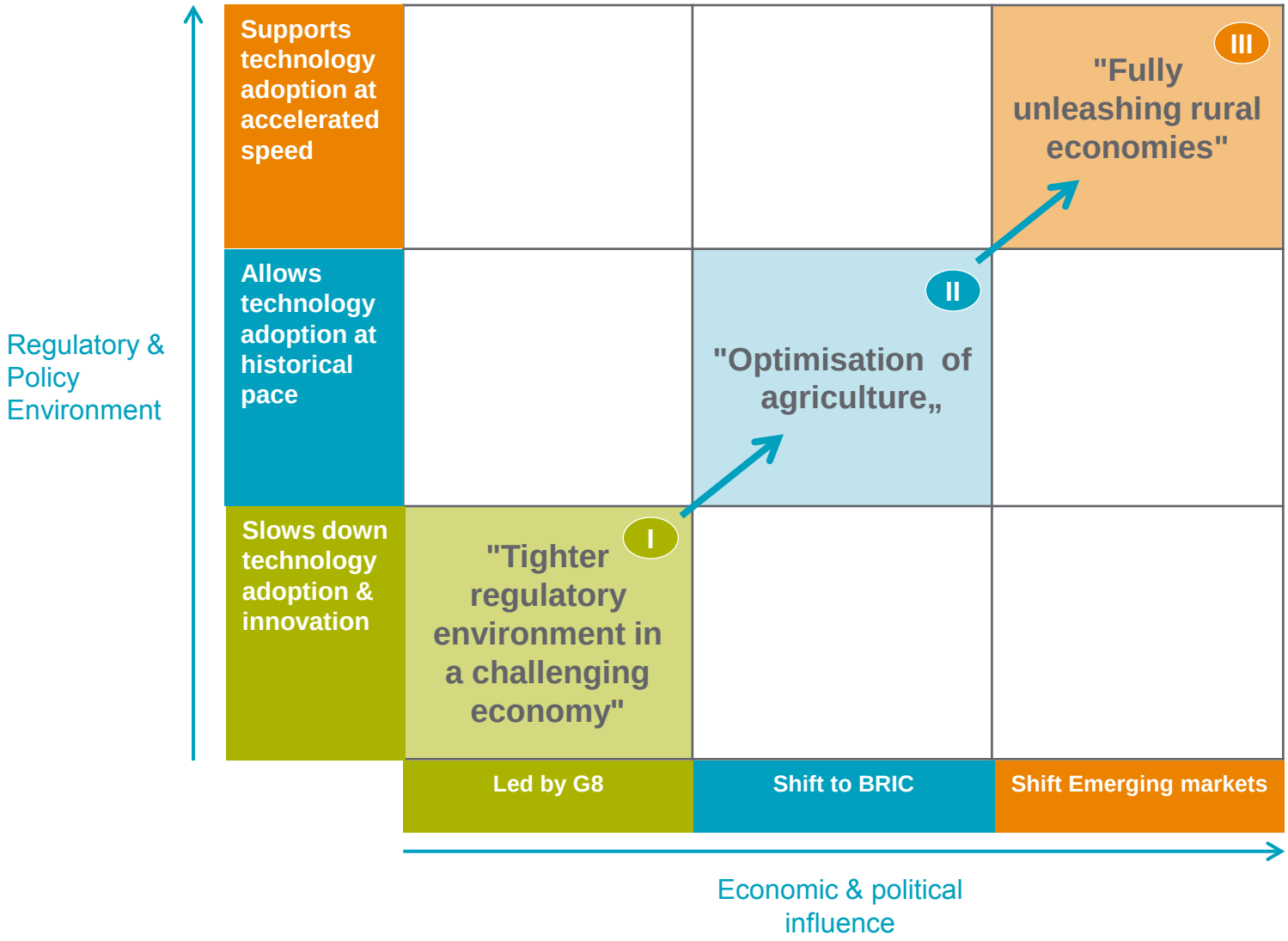
We need to build a model for agriculture production which is based on farm technology adoption and know-how…



… scenario one would require an amount of land brought into production equivalent to that used for farming in the USA

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The grower's world is increasingly complex

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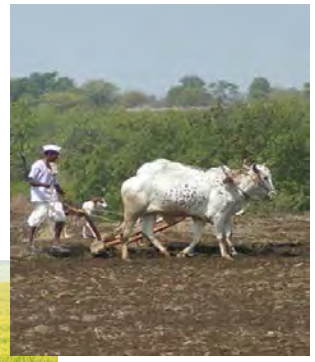
Sustainable Intensification of Agriculture

- Sustainable Intensification of Agriculture
  - **A key concept** from UK Foresight report
- ....defined as producing **more output from the same area** of land while **reducing the negative environmental impacts** and **using all inputs more efficiently** – land, water, nutrients
- Growing More from Less
- Rules nothing out and nothing in
- Applies to all farming systems





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New solutions needed that link technology, people and land

Improving farm productivity

- Enabling the right choices
- Accelerating innovation
- Sharing knowledge

Reducing agriculture's environmental footprint

- Preserving the land
- Saving water
- Protecting biodiversity

Building rural prosperity

- Building markets
- Valuing farm work
- Community development

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Development of integrated solutions

Increasing level of integration and risk mitigation

Pest (IPM)

Threshold Concepts

Beneficials Management

Traps, Pheromones

Resistance Management

Crop (ICM)

Programs

Altenative Solutions

Residue Minimization

Seed Care

Product Stewardship

Forecast Models

Alert Systems

Field / Farm

Field Margins

Pollinator Habitat

Application Technology

Farm Stewardship

C / N Footprint

Landscape

Refuge Management

Biodiversity Concepts

Water Protection

Land Use Concepts

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With inititiatives such as Operation Pollinator creating farmland habitats can be created for high biodiversity

Limited value plants & invertebrates

Simple structure & composition

Crop

Very visual
Attractive to the widest range of invertebrates & butterflies (8X)

Wildflower Mix

Good for invertebrates (4X bugs & spiders) & small mammals

Tussocky Grass

Best for Bumblebees & butterflies (13x)
Pollen & nectar abundant

Pollen & Nectar Mix

Achieving safety all around

Toxicology

Food

People

Protection of employees

Operator safety

Environment

Environment

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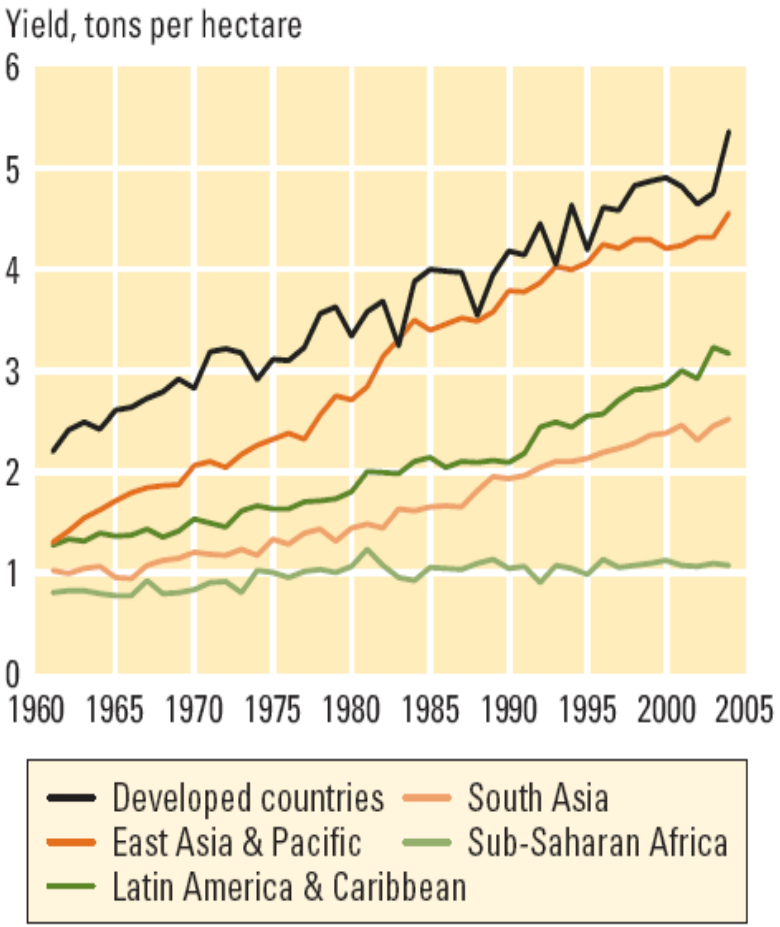
But fundamental needs of growers still need to be addressed

- Protecting yield
  - Biotic Stress – pests, disease, weeds, nematodes, bacteria, viruses
  - Abiotic stress – drought, cold, heat
  - Management of resistance
- Increasing yield
  - High yielding plant varieties
  - Crop enhancement
  - Nutrient use efficiency
- Improving yield quality
    - Taste, dietary components
    - New uses e.g. as biofuels
    - Oil composition, baking quality, reduction in mycotoxin levels

Technology has significantly contributed to yield since 1950's and must continue to do so



Source: http://faostat.fao.org, accessed June 2007.

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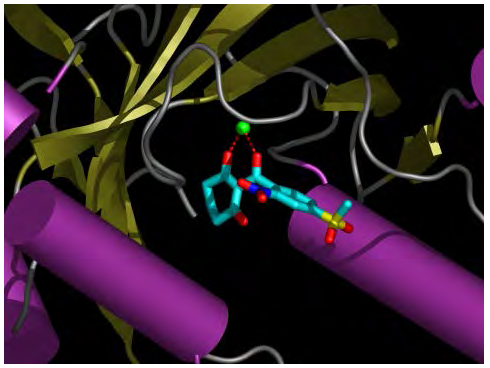
Enabling technologies in the biosciences are advancing

- **Genome engineering**: plant transformation, trait stacking, RNAi, synthetic biology etc.
- **Breeding technologies:** double haploids, hybridization systems, quantitative genetics, genetic markers
- **Bioinformatics and 'omics:** genomics, proteomics, metabolomics, data integration and mining

Underpinned by developments in the public sector: DNA sequencing, functional genomics, epigenetics, biosynthetic and signaling pathway elucidation, proteomics, systems biology

And certainly the biosciences are not the only technologies

- Chemical design tools e.g. x-ray crystallography
- Phenotyping and measuring technologies for field, greenhouse and lab
- Seed technologies : seed coating, seed priming
- Precision agriculture and logistics
- Modeling for chemical design, environmental studies, field resistance, pathway and network analysis
- Chemical process, formulation, application technologies
- Analytical techniques: for small molecule, protein, polymers



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Innovation is alive and well delivering a range of solutions!

- Protecting yield
  - Biocontrols and natural products from micro organisms – new research platforms developing, IPM and beneficial insect product refreshment
  - New chemistry - steady stream of new and improved products
  - Varieties tolerant to abiotic stress e.g. drought tolerant corn
  - Crops engineered to be tolerant to biotic stress
- Increasing yield
  - New high yielding plant varieties and hybridisation technologies in cereals
  - Chemistry for Crop Enhancement – e.g. strobilurins
  - Varieties with improved NUE – eg. phosphates, nitrogen
- Improving yield quality
  - New vegetable varieties with nutrient, flavour, processing improvements
  - Biofuel attributes – enzyme digestion of corn for the ethanol industry
  - Oil composition, baking quality, reduction in mycotoxin levels

Crop protection active ingredient innovation is delivering

- Major global R&D companies continue to bring new Active Ingredients to Market
  - Maize and Sugar cane herbicide (HPPD)
  - Broad spectrum fungicide family (SDHI's) – foliar and ST
  - New insecticides based on bisamide chemistry

2 sprays IZM 0.75 + Proline 0.4
13.6t/ha (+5.1t/ha)

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Seed care and drought tolerance: chemicals complementing genetics

- Abiotic stresses are responsible for more than 50% yield reduction
  - drought, heat, salinity, UV light, nutrient deficiency etc.

- Cruiser® shown to activate proteins that protect against stress, and stimulate root growth

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Crop enhancement in wheat

Combining knowledge of chemistry and genetics:

- Seed Care for bigger roots, vigor

  Cruiser®

- Improved water, nitrogen use efficiency, = yield +15-25% and reduced irrigation - water savings 15%

  Moddus®

- Greener leaves and improved grain quality

  Amistar®

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Improving cereals productivity through Hybrid Barley

- First hybridization of cereal seed
- Unmatched yield potential at a consistent level
- Improved tolerance of climatic variations
- Efficient & simple with a 3:1 return for the grower

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Angello™ Peppers – an environmentally sustainable consumer innovation

Dedicated breeding program

- 25% sweeter than standard peppers
- completely seedless
- average weight of 10-30g

Agronomic protocols maximize yield & minimize pesticide residues

Improved shelf life

Crunchy texture making it an ideal snack for children and adults

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Plant Breeding for Robust Resistance

- Big opportunity for disease control
- Single gene changes often limited effect
- Modern genetics and breeding technologies
  - Sugar beet with rhizomania resistance
- Less successful to date for Insect Resistance
  - Notable exception GM cotton, maize

Corn Pest control: Innovative combinations

Pest	Common Name	Vip3A (Viptera)	Cry1Ab (CB)
Helicoverpa zea	Corn Earworm	✓	✓
Spodoptera frugiperda	Fall Armyworm	✓	✓
Agrotis ipsilon	Black cutworm	✓	
Striacosta albicosta	Western bean cutworm	✓	
Papaipema nebris	Common stalk borer	✓	✓
Ostrinia nubilalis	European corn borer		✓
Diatraea grandiosella	Southwestern corn borer	✓	✓

Corn root worm resistant maize

Corn borer resistant (Bt) maize

Stacks offer outstanding control of all these pests

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Innovation in traits for Insect control?

- Bt proteins for control of lepidoptera/coleoptera
- VIP distinct mode of action
  - stacked traits to complete spectrum and help manage resistance
- Programmes with chemicals
- Refugia concepts
- RNAi – a new paradigm for pest control?
  - See for example Monsanto **WO11112570**

Corn engineered to contain starch degrading enzyme

- Enogen® corn is bio-engineered to enhance the productivity and efficiency of dry grind ethanol production.
- Contains alpha amylase enzyme directly in the endosperm of the grain.
- Eliminates the need to use liquid alpha amylase enzyme in the production process
- Drives improvements in ethanol plant throughput, efficiency and profitability.

Water optimization :
Agrisure Artesian™ Technology

- Drought during pollination leads to poor kernel set
- Through gene association mapping, **multiple genes** are identified.
- Gene have distinctive **multiple modes of actions responsible** for moisture stress
- Potential impacts across **all stages of plant development.**.
- Genes are inserted into **elite hybrids** for testing and evaluation in managed stress environments, dryland, limited irrigated, irrigated and non-irrigated acres.

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Gro N Tec: grower optimization & technology

Create value by optimizing pepper and tomato fruit production through abiotic stress based solutions & technologies

- advannced measurement of key agronomic factors
- partnerships with growers to build know-how & continuous improvement

Sustainable production through reduction of water & fertilizer volumes

Cannon pepper variety growers improving yields by +20%

Under development in Spain, Turkey & Mexico

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TEGRA: transforming rice production

Tegra

Securing yield and reducing labor for smallholders: introducing a revolutionary transplanting system

30% yield advantage

150% return on investment

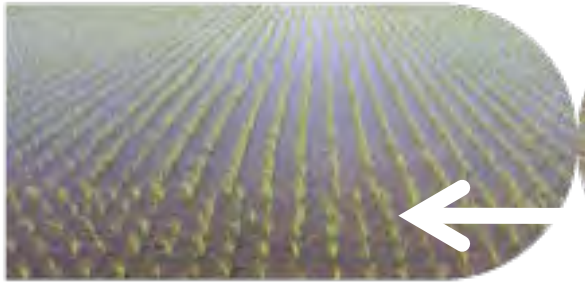
Preferred retailers place direct Farmer orders

High quality treated seeds

Integrated technology in seedling tray

Nursery franchisees raise healthy seedlings

Transplant franchisees offer seedlings-in-the-field



Agronomy protocol to maximize yields

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PLENE: Focus on efficiency and sustainability

Plene

The first integrated mechanized planting system for sugar cane

15%
Cost reduction for growers

Healthy seedlings production at Syngenta nurseries

- Disease-free
- Traceable
- Genetic warranty

Production and processing units

- Cleaning and cutting
- Treatment with Syngenta technologies
- Packaging

Planting

- Minimal tillage
- High productivity
- Better use of natural resources

Labor

- Less manpower
- Greater efficiency
- Better working conditions

Continued value creation

- Faster germination
- Increased resistance
- Complete crop protection program
- Greater convenience and reduced cost

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Integrated Crop Management in Vegetables

- **Andalucia (Almeria) Spain**
  - 2008- 100% of peppers, cucumbers and egg plant treated with ICM
  - Combination of cultural, chemical and biological control methods

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Integrated Weed Management

- Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations
- Herbicides are the foundation of weed control…
- Programs for herbicide-resistance management must consider use of all cultural, mechanical, and herbicidal options available for effective weed control in each situation
- Don’t think of a new Herbicide with a new moa as a “silver bullet”
- Think - “How can this product fit best into a system that provides sustainable control of weeds”
  - Mechanisation, soil nutrients, genetics and chemicals – plus agronomic practices

Norsworthy et al. Weed Science 2012 Special Issue:31–62

Biocontrol of Varroa Mite

- Entomopathogenic fungi as potential biocontrol agents of the ecto-parasitic mite, Varroa destructor, and their effect on the immune response of honey bees (*Apis mellifera* L.)*

- *Metarhizium anisopliae, Beauveria bassiana and Clonostachys rosea* Entomopathogenic fungi could reduce Varroa mite damage to honey bee brood by both infecting the parasite and preventing Varroa-associated suppression of honey bee immunity.

* Mollah et al. Journal of Invertebrate Pathology 111 (2012) 237–243

Biological control of insects: Syngenta Bioline

Predatory mites

- *Amblyseius cucumeris* – thrips
- *A. swirskii* – whitefly
- *A.andersoni* – spider and russet mites
- *Phytoseuilus persimilis* - spidermites
- *Hypoaspis miles* - sciarids

Parasitoids

- *Encarsia* and *eretmocerus* – whitefly
- *Aphidius* – aphids
- *Diglyphus* - leafminer

Bugs

- *Orius sp* – thrips
- *Macrolophus* - whitefly

Intensive vegetables, flowers and ornamentals as part of a management program

Summary

- Growers have many challenges to face
- Pests, Weeds and Diseases continue to be a major cause of yield and crop quality loss, and farm income reduction
- Continued innovation is an imperative for food security
- Many tools are developed and need to be available to all
- Chemical crop protection agents are essential to meet the global food security challenge
- Advances in plant science offer an opportunity for better genetics for pest and disease resistance
- Systems approaches are vital
- Sustainability is essential and achievable

Bringing plant potential to life

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