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Food Technology-2015
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Global food security, sustainability and safety: the 21st Century challenge

Professor Malcolm Elliott

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Editor in Chief

Agriculture and Food Security

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- **Food security** exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (World Food Summit, 1966).
- **Sustainability** – the use of resources at rates that do not exceed the capacity of the earth to replace them. Key issues are water and soil quality, biodiversity and climate change.
- **Food safety** – production, handling, preparation and storage of food in ways that prevent food borne illness.

Secure, safe food facilitates perfect health





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The Telegraph

Britain's obesity epidemic fuelled by sheer abundance of food



By Sarah Knapton, Science Editor, 30th June 2015

Britain's obesity epidemic is being fuelled by the sheer abundance of food, researchers have warned, after finding that there are around 50% more calories available to each person than needed.

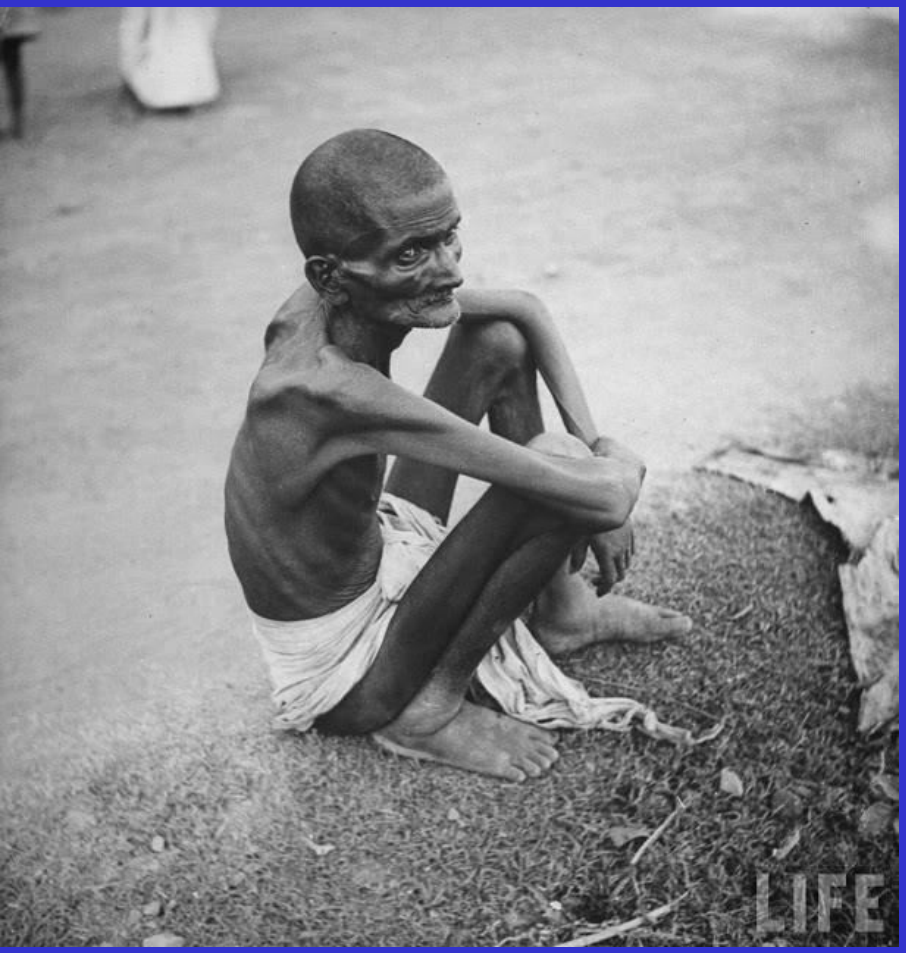
In Britain, 25% of adults are obese – 12 million people – compared with fewer than 3% in the Seventies. The proportion is predicted to grow to 1 in 3 by 2030 and more than half by 2050.

The study published in the Bulletin of the World Health Organisation found that the obesity rate has increased as food has become more easily available and calorific.

Food security

Thomas Malthus (*An Essay on the Principle of Population as It Affects the Future Improvement of Society, 1798)* argued that population increase will always tend to outrun the growth of production. The increase of population will take place, if unchecked, in a geometric progression, while the means of subsistence will increase in only an arithmetic progression. Population will always expand to the limit of subsistence and will be held there by **famine**, war, and ill health.

Famine



Throughout history nearly every continent in the world has experienced a period of famine. Each year 9,000,000 people worldwide die because of hunger and malnutrition (one every 3.5 seconds); 5,000,000 are children. Before the end of this Century the world's population will exceed 10,000,000,000.

Famine has been a recurrent feature of life in the Indian sub-continent. The last major famine was the Bengal famine of 1943. Drought was responsible for that famine. It is estimated that over three million people died from starvation, malnutrition and related illnesses during the Bengal famine.

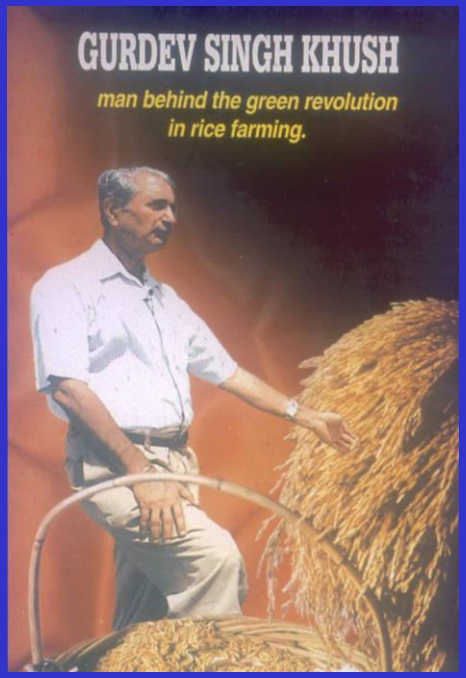
"The Population Bomb"

In the late 1960s, most experts were predicting further global famines in which billions would perish. "The battle to feed all of humanity is over," biologist Paul Ehrlich wrote in his 1968 best seller *The Population Bomb*. "In the 1970s, hundreds of millions of people will starve to death in spite of any crash programs embarked upon now." Ehrlich also said, "I have yet to meet anyone familiar with the situation who thinks India will be self-sufficient in food by 1971." He insisted "India couldn't possibly feed 200 million more people by 1980."

Architects of the green revolution

The Green Revolution involved the breeding of improved wheat, new types of higher-yield rice, and more efficient use of fertilisers and water to provide higher crop yields.

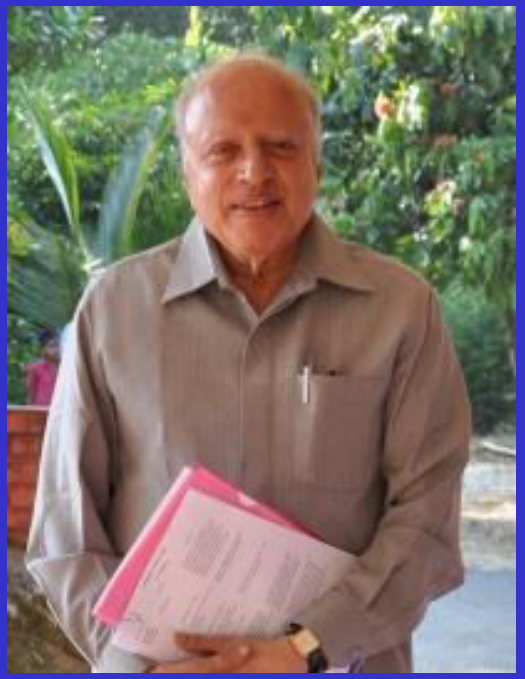
Professor Gurdev S Khush Awarded the World Food Prize in 1996



Dr. Norman E. Borlaug Awarded the Nobel Peace Prize in 1970



Professor M S Swaminathan Awarded the World Food Prize in 1987

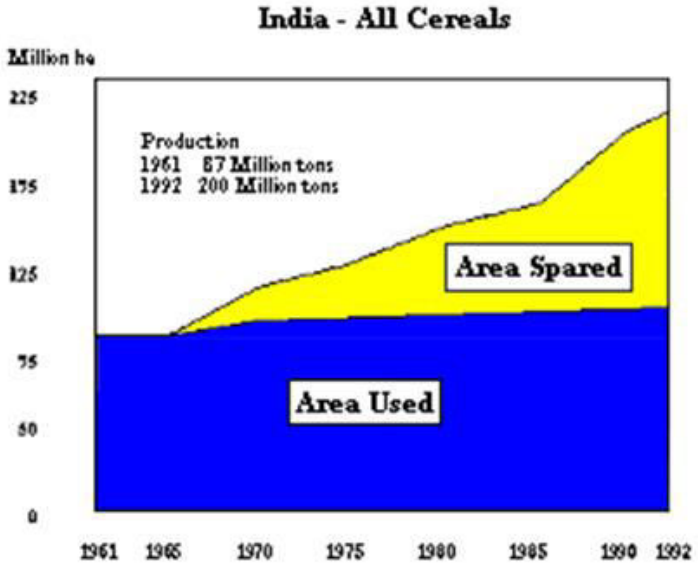


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High-yield techniques are saving ecosystems from destruction.

The land that Indian farmers spared through raising yields*



*The upper curve shows the area that would have been needed to achieve 1988-90 production had 1938-40 yields still prevailed. The lower curve shows the area that was actually harvested.

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The once abundant Bengal tiger population of India has fallen to an estimated 40,000, and it is listed as an endangered species. The destruction of the tiger's forest habitat, trophy hunting, commercial hunting, and killing in order to protect domestic livestock have all contributed to the decline of these magnificent animals.



Obesity



The Daily Telegraph

Saturday, September 30, 1995

Damning health report 'withheld'

Alarm over
huge rise
in obesity

The world has some 7,300,000,000 people

2,100,000,000 of them are obese or overweight, while colossal amounts of food are wasted (in the USA almost 50% of harvest-ready food is not eaten)

Hunger



The world has some 7,300,000,000 people

Approximately 805,000,000 of them suffer from hunger (deficiency of calories and proteins) while more than 2,000,000,000 people have micronutrient (vitamins and minerals) deficiency

Each year 9,000,000 people die because of hunger and malnutrition (one every 3.5 seconds);
5,000,000 are children

In fifty years time the world's population will approach 10,000,000,000



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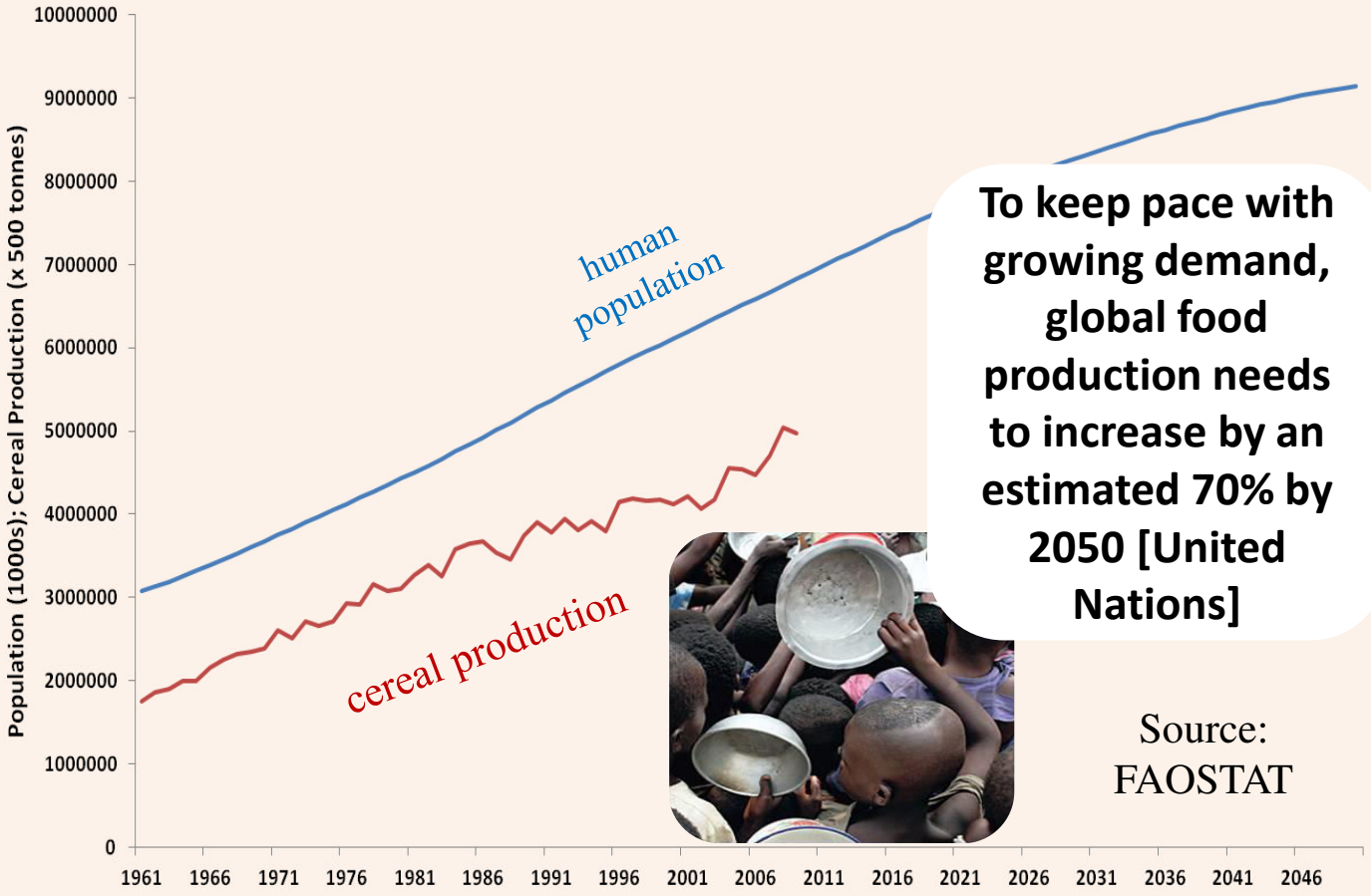
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Can future demand be met ?



To keep pace with growing demand, global food production needs to increase by an estimated 70% by 2050 [United Nations]

Source: FAOSTAT

Bruce (2010) *Food Security* 2: 133-141

By 2050 we must enhance the world's food supply by 70%



80% of that future growth must come from land that is already in use.

Most of the increase in production must occur in the countries where it is consumed

There is limited potential for land expansion, except in the Americas and Sub-Saharan Africa

Expansion of irrigation is crucial if we are to meet the food demand

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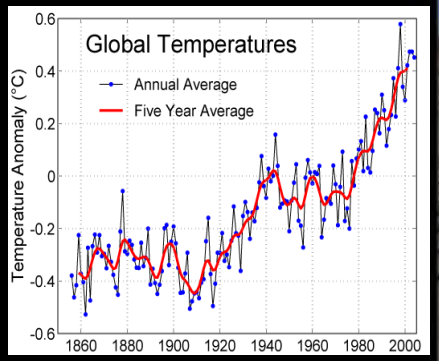
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Irrigated agriculture



- Irrigation is responsible for 70% of global water withdrawals
- 17% of cultivated land is irrigated (275 million ha, 200 million in developing countries)
- 40% of the world's food is harvested from irrigated land (57% of cereal production)
- The FAO says that by 2030 the world's irrigated area must increase by 50 million ha.

Global climate change





Droughts



Crop Damage



Floods



Storm Damage



Forest Fires



Melting Ice Pack

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www.observer.co.uk
Sunday 14 April 2013 £2.50

The Observer

Millions face starvation as world warms, say scientists

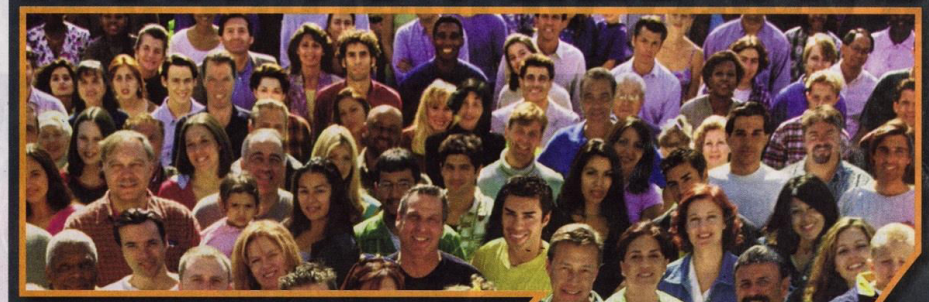
- Parts of Africa will be disaster areas
- World unprepared, say food experts

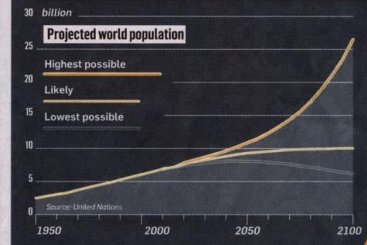
by John Vidal

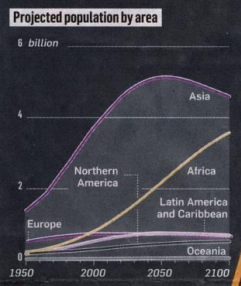
Millions of people could become destitute in Africa and Asia as staple foods more than double in price by 2050 as a result of extreme temperatures, floods and droughts that will transform the way the world farms.

THE SUNDAY TIMES
thesundaytimes.co.uk
30.10.11

HOW TO FEED THE bn







Five key countries

	1950	2010	2050
India	370m	1.2bn	1.7bn
China	550m	1.3bn	1.3bn
Nigeria	37m	158m	390m
Indonesia	75m	240m	293m
Ethiopia	18m	83m	145m

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THE CHALLENGE

We must DOUBLE Crop Production by 2050 with FEWER resources (arable land, water, fertilizers, agrochemicals, fuel, etc.)

- **NO SINGLE APPROACH can feed some 9 billion people in 2050 and some 10 billion people in 2100**
- **Conventional crop improvement ALONE will not double crop production by 2050 – GM CROPS are NOT a panacea but they are essential**
- **The successful strategy must have MULTIPLE APPROACHES that address all the principal issues including:**

- **Population stabilization – Africa 3.6 billion people in 2100 out of 10.1 billion**
- **Improved food distribution systems, and less wastage**
- **A technology component – The crop improvement strategy must integrate the BEST of the CONVENTIONAL and the BEST of the NEW (molecular) approaches to optimize productivity, contribute to food, feed and fibre security and address climate change**

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Source: Clive James, 2012

The Opportunity: Plant Biotechnology

REDUCED STRESS

- Pests & diseases
- Weeds
- Saline or acid soils
- Drought or flooding
- High or low temperature





MORE SUSTAINABLE PRODUCTION

IMPROVED PLANT PERFORMANCE

- Efficiency of water and nutrient use
- Control of flowering
- Plant architecture

PLANT GENE TECHNOLOGY

IMPROVED NUTRITION AND HEALTH

- Vitamins & minerals
- Post harvest quality
- Taste
- Proteins
- Oils
- Carbohydrates
- Fibre & digestible energy

NEW INDUSTRIES

PHARMACEUTICALS

- Vaccines
- Antibodies
- Diagnostics

CHEMICAL FEEDSTOCKS

- Biodegradable plastics
- Biofuels
- Phytoremediation

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Plant Biotechnology

- Proven Benefits
- Global Adoption
- Safety Record
- Promising Future

GLOBAL IMPACT of GM CROPS

- **IMPROVED PRODUCTIVITY AND INCOME** – Farm income gains of **$78 billion from 1996 to 2010,** of which **40%** was due to cost reduction and **60%** due to a production gain of **276 million tons; these calculated benefits are conservative due to spill-over from GM to conventional crops.**
- **PROTECTS BIODIVERSITY** – **276 million tons would require an extra 91 million Ha** – biotechnology is a land saving technology. The strategy is to double crop production on the same area of 1.5 billion Ha of crop land – **saves forests/biodiversity – 13 million Ha lost/year.**
- **ENVIRONMENTAL IMPACT** – Reduced need for external inputs
  - **Saving of 443 million kg pesticides from 1996/2010 – 9% saved**
  - **Saved 19 billion kg $C0_2$ in 2010 - contribution to climate change**
  - **Conservation of soil and water through GM crops (no/low till)**
- **HUMANITARIAN BENEFITS**
  - **Contribution to poverty alleviation of some 15 million small resource-poor farmers, and their families, about 50 million people in 2011 alone**

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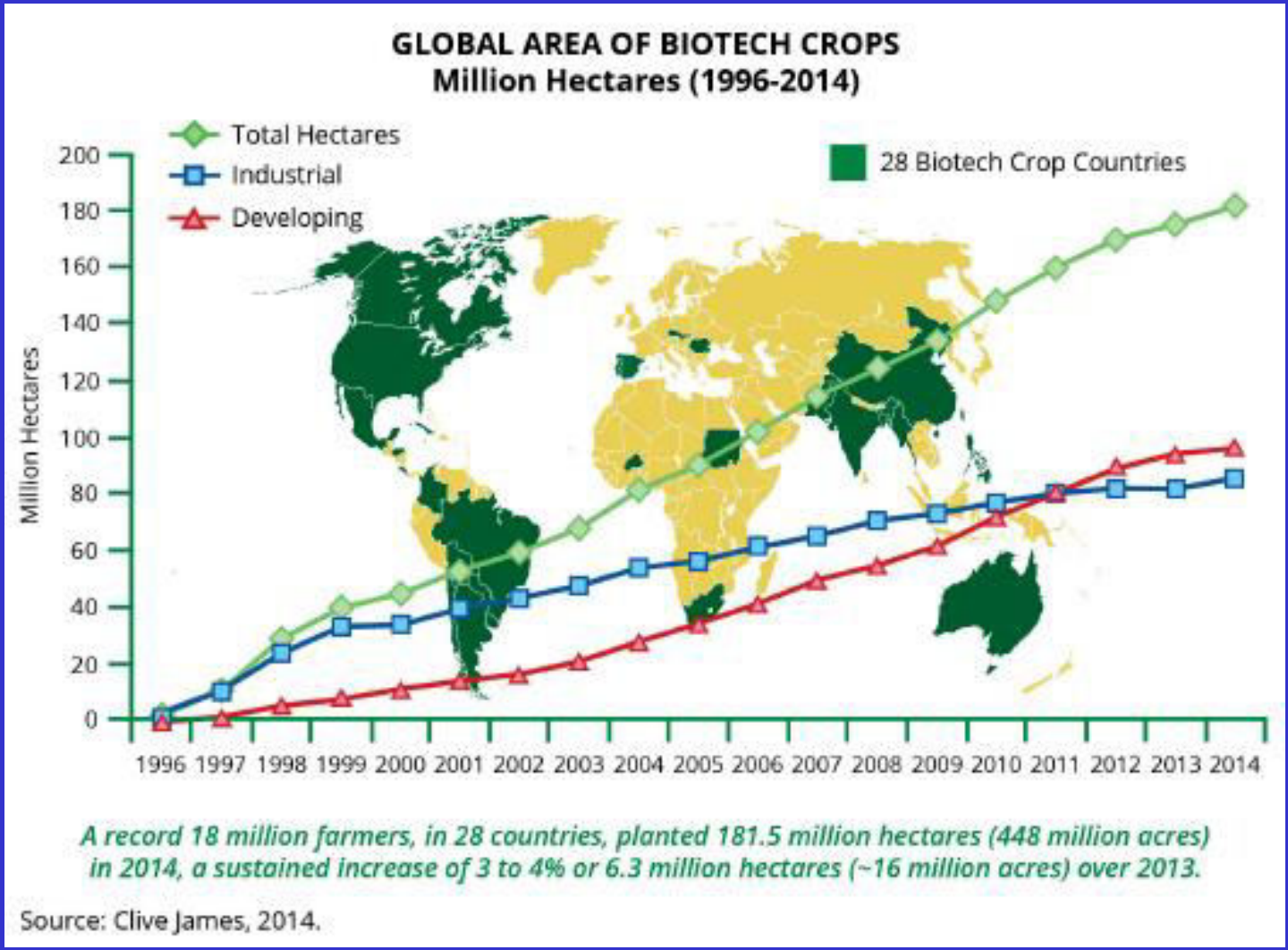
for Global Food Security

Source: Brookes and Barfoot, 2012; Clive James, 2012

Plant Biotechnology

- Proven Benefits
- ➢ Global Adoption
- Safety Record
- Promising Future

Farmers Are Choosing to Plant More GM/Biotech Crops Each Year: Benefits Drive Adoption



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Plant Biotechnology

- Proven Benefits
- Global Adoption
- ➢ Promising Future
- Safety Record

Quality Traits eg Bio-fortification

500 000 children per year go blind and up to 6 000 per day die from vitamin A-malnutrition.

Many of them depend for their calories upon rice which lacks vitamin A and other micro-nutrients.



Biofortification – improvement of the micro-nutrient content of the crop on a genetic basis – could reduce malnutrition in a cost-effective and sustained manner.

Cost-effective and Sustainable Production of Nutritious Food

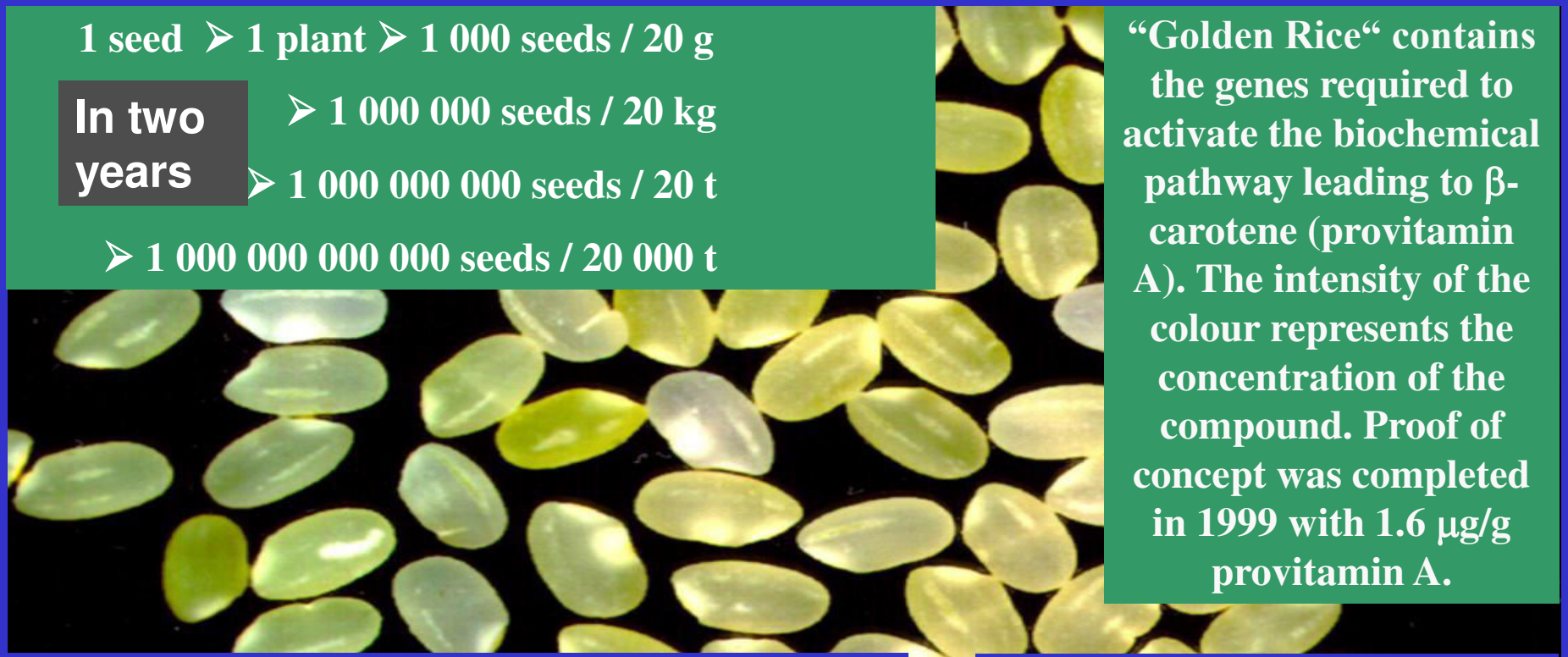
1 seed ➢ 1 plant ➢ 1 000 seeds / 20 g

In two years

➢ 1 000 000 seeds / 20 kg

➢ 1 000 000 000 seeds / 20 t

➢ 1 000 000 000 000 seeds / 20 000 t



"Golden Rice" contains the genes required to activate the biochemical pathway leading to β-carotene (provitamin A). The intensity of the colour represents the concentration of the compound. Proof of concept was completed in 1999 with 1.6 µg/g provitamin A.

All a farmer needs to benefit from this technology is one seed. He needs neither additional agrochemicals or pesticides nor novel farming systems or seeds. He uses part of his harvest for the next sowing. There are no new dependencies. The technology is free up to a yearly income from rice of $ 10,000 per farmer or local trader.

Each seed has the potential to produce, in two years, food for 100,000 poor people. And it carries the technology to reduce vitamin A-malnutrition in a cost-effective, sustainable manner.

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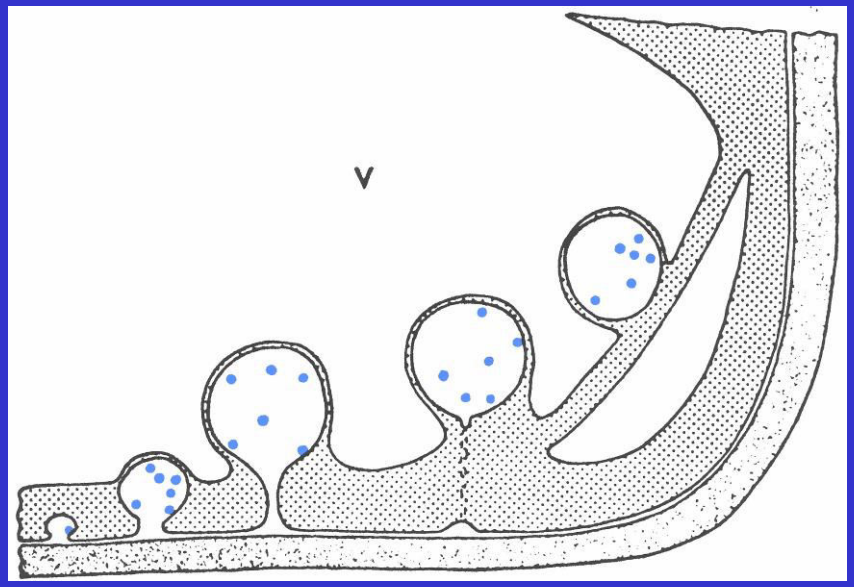
Nitrogen Fixing Cereals



Professor E C Cocking has established an International Network for research on Nitrogen Fixation in the World's major non-legume crops (especially rice, wheat, maize and sorghum). This involves basic studies of the interaction of crops with nitrogen fixing bacteria for the establishment of endosymbiotic nitrogen fixation. The research is providing the scientific breakthrough which will facilitate delivery of the Evergreen Revolution.

Reduction of Inputs of Synthetic Nitrogen Fertilizers

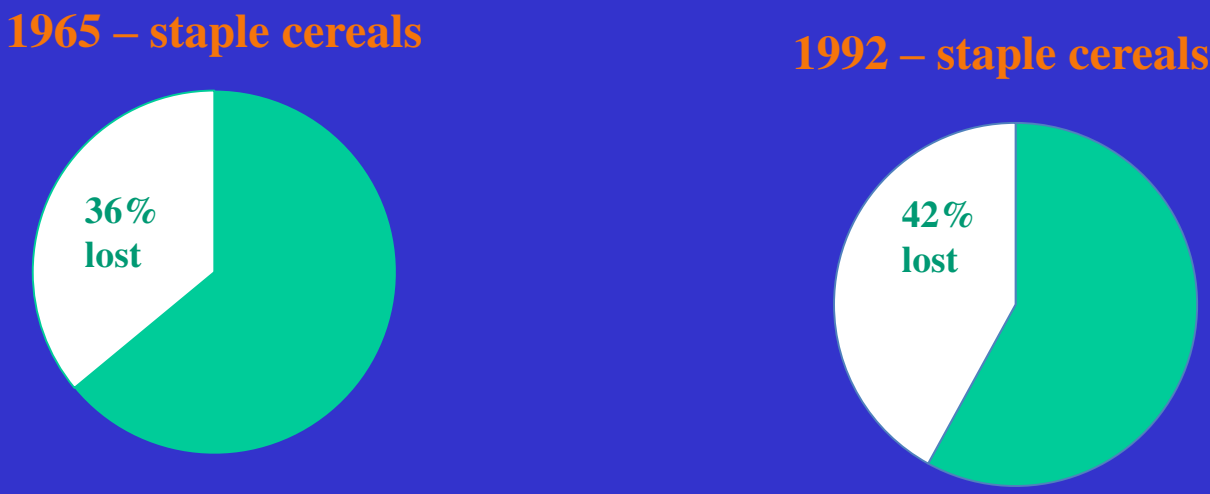
INTRACELLULAR COLONIZATION OF CEREALS AND OTHER CROP PLANTS BY NITROGEN FIXING BACTERIA



Source: Edward Cocking, 2004

If nitrogen-fixing bacteria (rhizobia or *Gluconacetobacter diazotrophicus*: blue dots) penetrate through the cell wall they can become internalized by endocytosis and are then present in symbiosome-like secondary vacuoles in the cytoplasm surrounded by the symbiosome membrane derived from the plant plasma membrane.

Impact of Pests, Weeds & Diseases



Crop losses caused by pests have not decreased since the 1960s, even with use of pesticides

SOURCE: Oerke & Dehne (2004) Crop Prot 23:275–285

Aphid Alarm Pheromone

- Naturally produced to warn other aphids when they are attacked by a predator
- Identified as **(*E*)-ß-farnesene** for many economically important aphids
- Peppermint plants also naturally produce (*E*)-ß-farnesene and the gene responsible for its biosynthesis has been isolated.

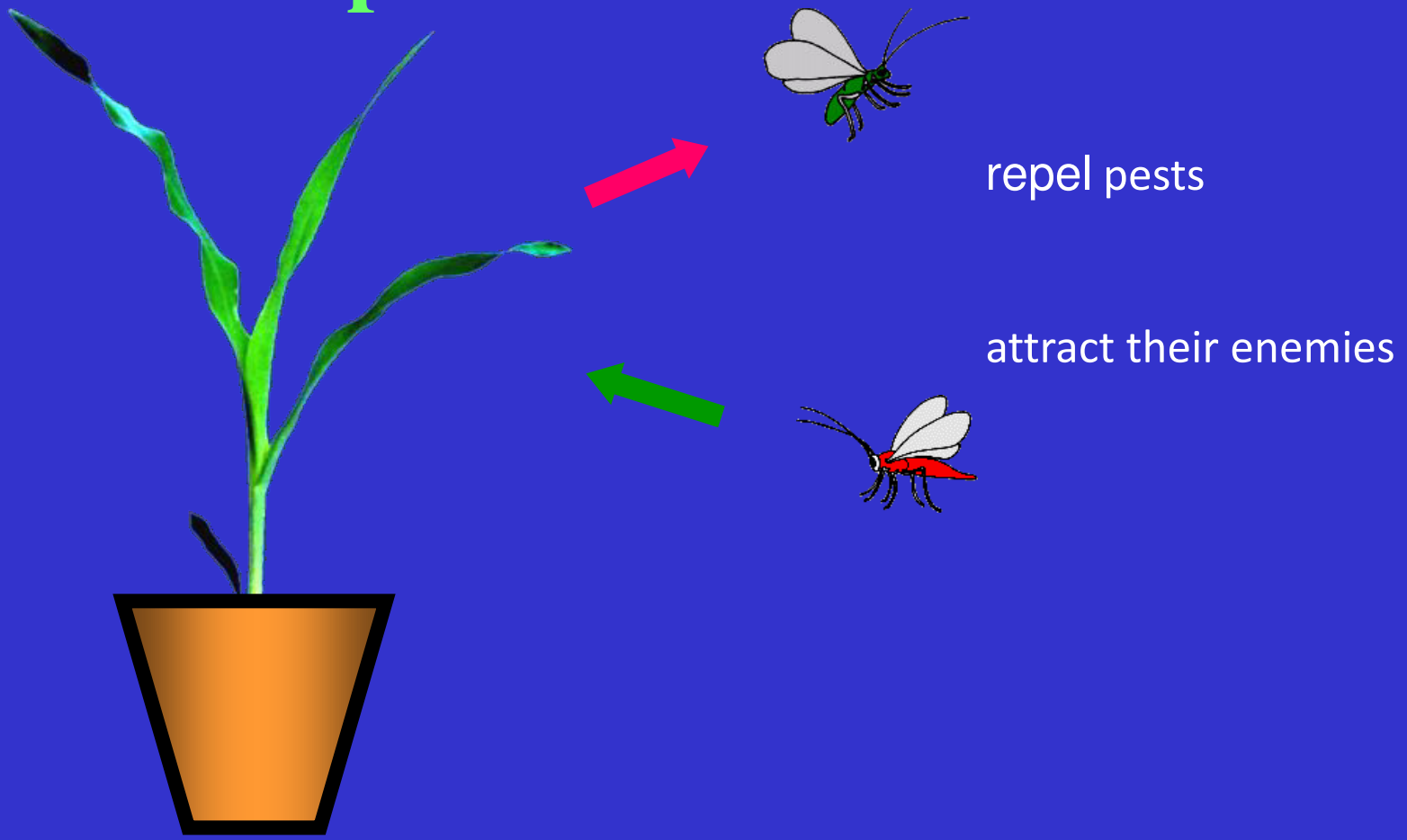






PLATE VII.—*Mentha piperita*. The source of Oleum Menthae Piperitae (peppermint oil). (From Jackson: *Experimental Pharmacology and Materia Medica.*)

A Pest Management Strategy Used by Rothamsted Research Scientists to Create Aphid Resistant Wheat



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Plant Biotechnology Can Deliver Food Security via an "Evergreen Revolution" which Produces Higher Yield, Higher Quality Crops with Lower Input and Lower Environmental Impact

- Improved photosynthesis
- Increased yield
- More efficient use of water
- More efficient use of minerals/fertilizers
- Tolerance to drought and salinity
- Reduced losses to pests and diseases with lower agrochemical applications
- Improved quality
- Novel products

Plant Biotechnology

- Proven Benefits
- Global Adoption
- Promising Future
- ➢ Safety Record

Commitment to Safety is the Top Priority Throughout the R&D Process

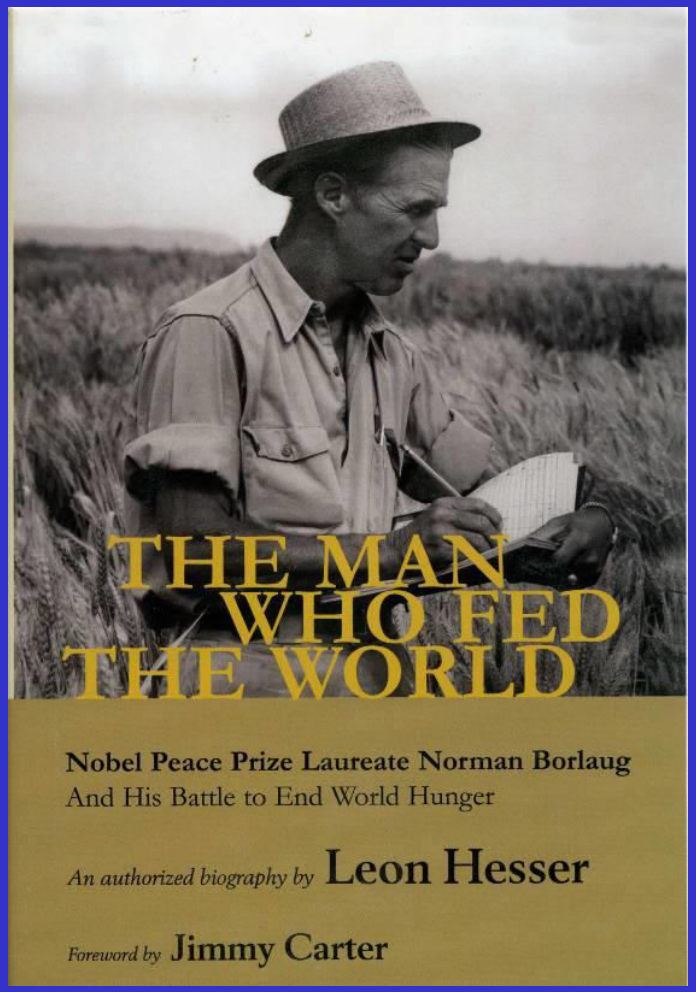


Safety assessment of genes / proteins	Testing and selection of lines and varieties	Comprehensive regulatory review	Continuous QC protocols, audits and standards
▪ Choice of genes ▪ Source of genes ▪ Ecology	▪ Equivalence ▪ Agronomics ▪ Efficacy	▪ Food ▪ Feed ▪ Environment	▪ Quality ▪ Purity ▪ Performance

Scientific Officials Report on the Safety and Benefits of Biotech Crops

- World Health Organization
- Food & Agriculture Organization (FAO) of the United Nations
- National Academy of Sciences (USA)
- Royal Society (UK)
- American Medical Association (USA)
- French Academy of Medicine
- European Commission
- U.S. Food & Drug Administration
- Society of Toxicology
- Institute of Food Technologists

Source: FAO, 2001.



Norman Borlaug, "The Man Who Fed the World", produced high –yielding, disease-resistant wheat varieties whose progeny are now grown on more than 80 million hectares of farmland. It has been calculated that some one billion people were saved from starvation by the Green Revolution which he initiated. When he accepted the Nobel Prize in 1970 he observed that "it is time that the tide of the battle against hunger was changed for the better – but ebb tide could soon set in if we become complacent." The harsh reality of this warning was recognised in the early part of 2008 when the price of wheat and maize doubled and that of rice tripled, leading to food riots in 20 countries.

£0.80 (IR €1.00)
Wednesday 09.04.08
Published in London and Manchester
guardian.co.uk

theguardian

Food price rises threaten global security - UN

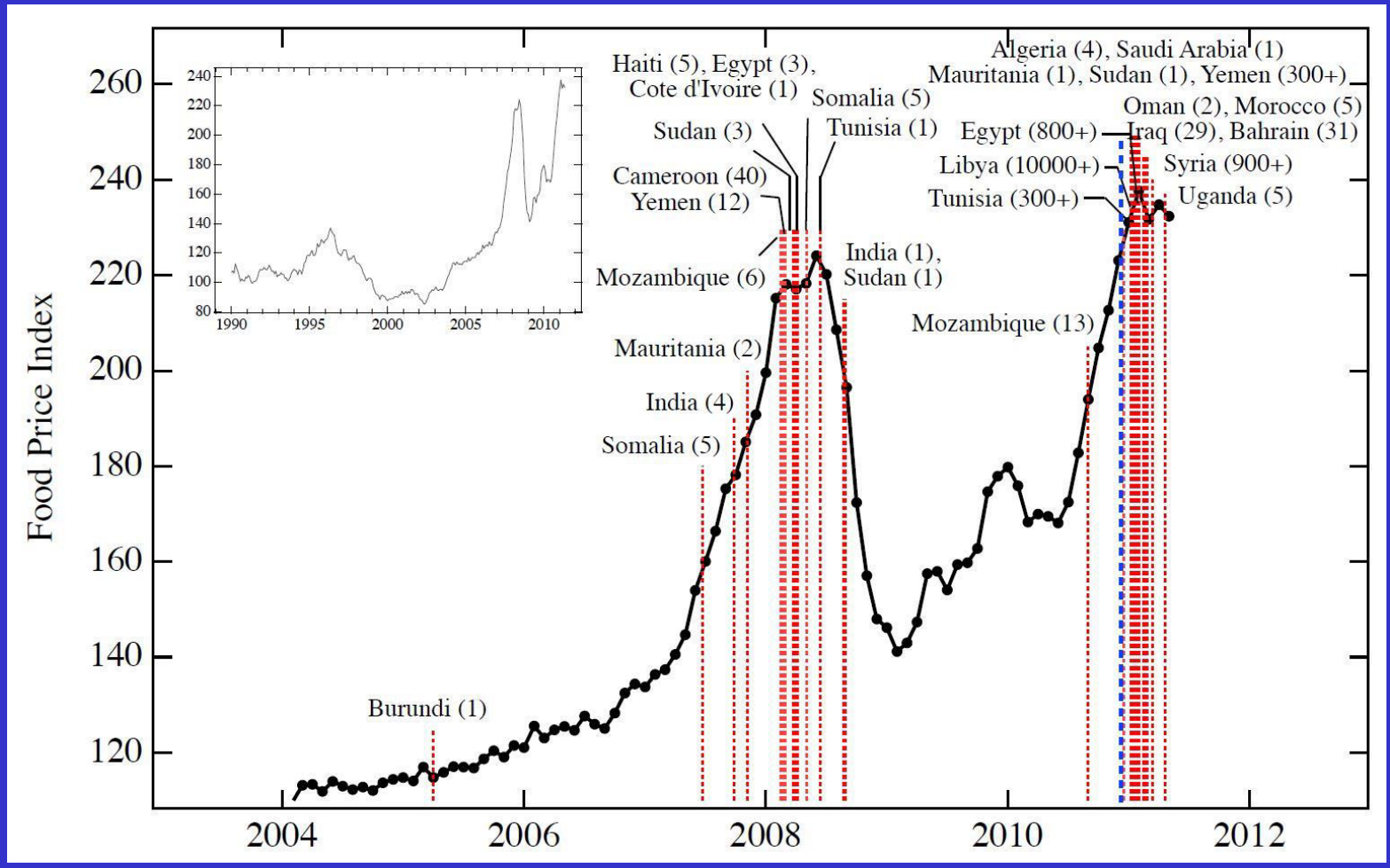
Hunger riots will destabilise weak governments, says senior official

David Adam, environment correspondent

Rising food prices could spark worldwide unrest and threaten political stability, the UN's top humanitarian official warned yesterday after two days of rioting in Egypt over the doubling of prices of basic foods in a year and protests in other parts of the world.



A farmer sprays pesticide at a rice field in the Karawang regency, Indonesia. Photograph: Beawiharta/Reuters

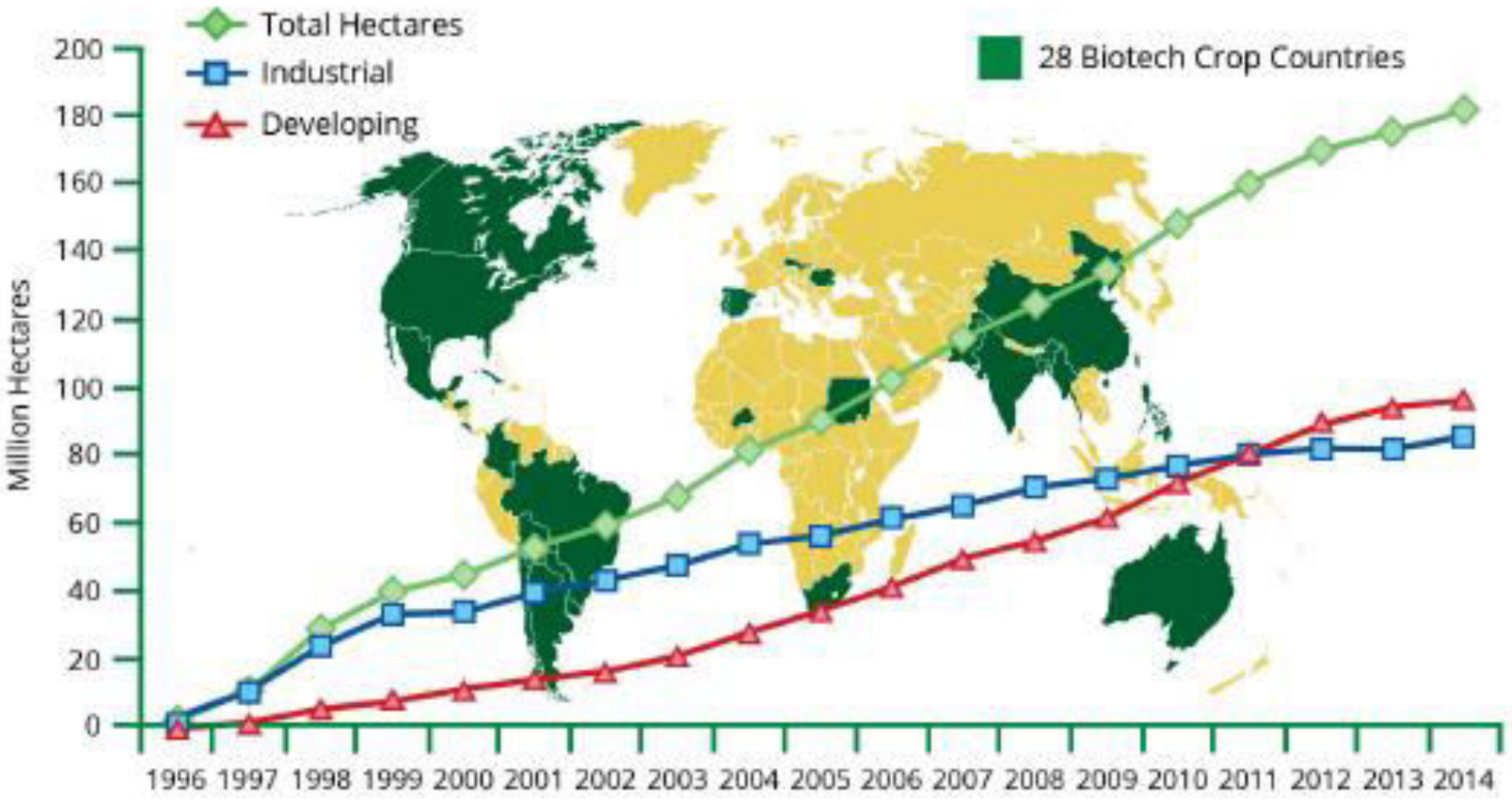


Food prices spikes are correlated with increases in food riots. Red dashed vertical lines correspond to beginning dates of "food riots" and protests associated with the major unrest in North Africa and the Middle East. The overall death toll is reported in parentheses. The insert shows the FAO Food Price Index from 1990 to 2011.

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GLOBAL AREA OF BIOTECH CROPS
Million Hectares (1996-2014)



A record 18 million farmers, in 28 countries, planted 181.5 million hectares (448 million acres) in 2014, a sustained increase of 3 to 4% or 6.3 million hectares (~16 million acres) over 2013.

Source: Clive James, 2014.

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The Daily Telegraph

Speed up roll-out of GM crops, says Downing Street.

European Union bureaucrats are being urged by David Cameron to let more farmers grow genetically-modified crops in the UK.



Prime Minister David Cameron Photo: AFP

BY CHRISTOPHER HOPE, SENIOR POLITICAL CORRESPONDENT 10 DEC 2012

DOWNING STREET SAID IT WAS WORKING BEHIND THE SCENES TO ENCOURAGE EUROPEAN COMMISSION OFFICIALS TO MAKE IT EASIER FOR FARMERS TO GROW GM CROPS.

THE NEWS CAME AFTER OWEN PATERSON, THE ENVIRONMENT, FOOD AND RURAL AFFAIRS SECRETARY, SAID IN AN INTERVIEW WITH *THE DAILY TELEGRAPH* THAT GM FOOD SHOULD BE GROWN AND SOLD WIDELY IN BRITAIN.