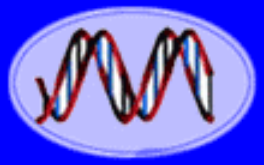
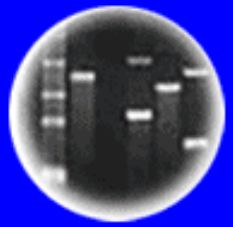


DNA
Genetic Code of Life

Entire Genetic Code
of a Bacteria



DNA Fingerprinting

Cloning: Ethical Issues
and Future Consequences

Plants of Tomorrow

HC70A, PLSS530, & SAS70A
Winter 2013
Genetic Engineering in Medicine, Agriculture, and Law

Professors Goldberg, Prakash & Harada

Prakash Lecture – January 24, 2013

Engineering Crops for the Developing World

UCLA

TUSKEGEE UNIVERSITY

UCDAVIS
UNIVERSITY OF CALIFORNIA

Food Eaten in One Week

United States

http://www.antalik.com/how-much-food-is-eaten-around-the-world-in-one-week/

Food Eaten in One Week

Egypt

http://www.antalik.com/how-much-food-is-eaten-around-the-world-in-one-week/

Food Eaten in One Week

Ecuador

http://www.antalik.com/how-much-food-is-eaten-around-the-world-in-one-week/

Food Eaten in One Week

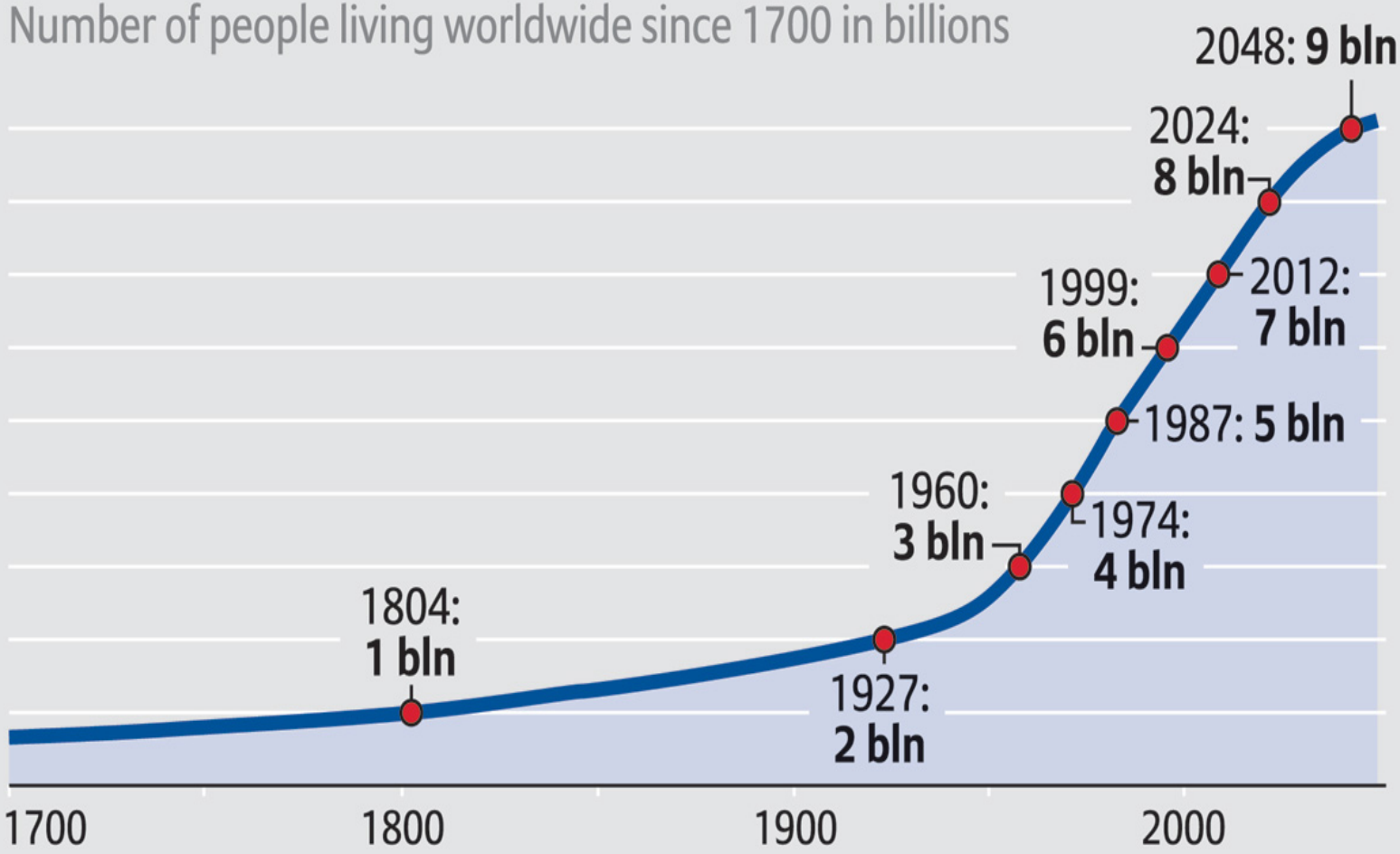
Chad

http://www.antalik.com/how-much-food-is-eaten-around-the-world-in-one-week/

POPULATION OF THE EARTH

Allianz

Number of people living worldwide since 1700 in billions



Source: United Nations World Population Prospects, Deutsche Stiftung Weltbevölkerung

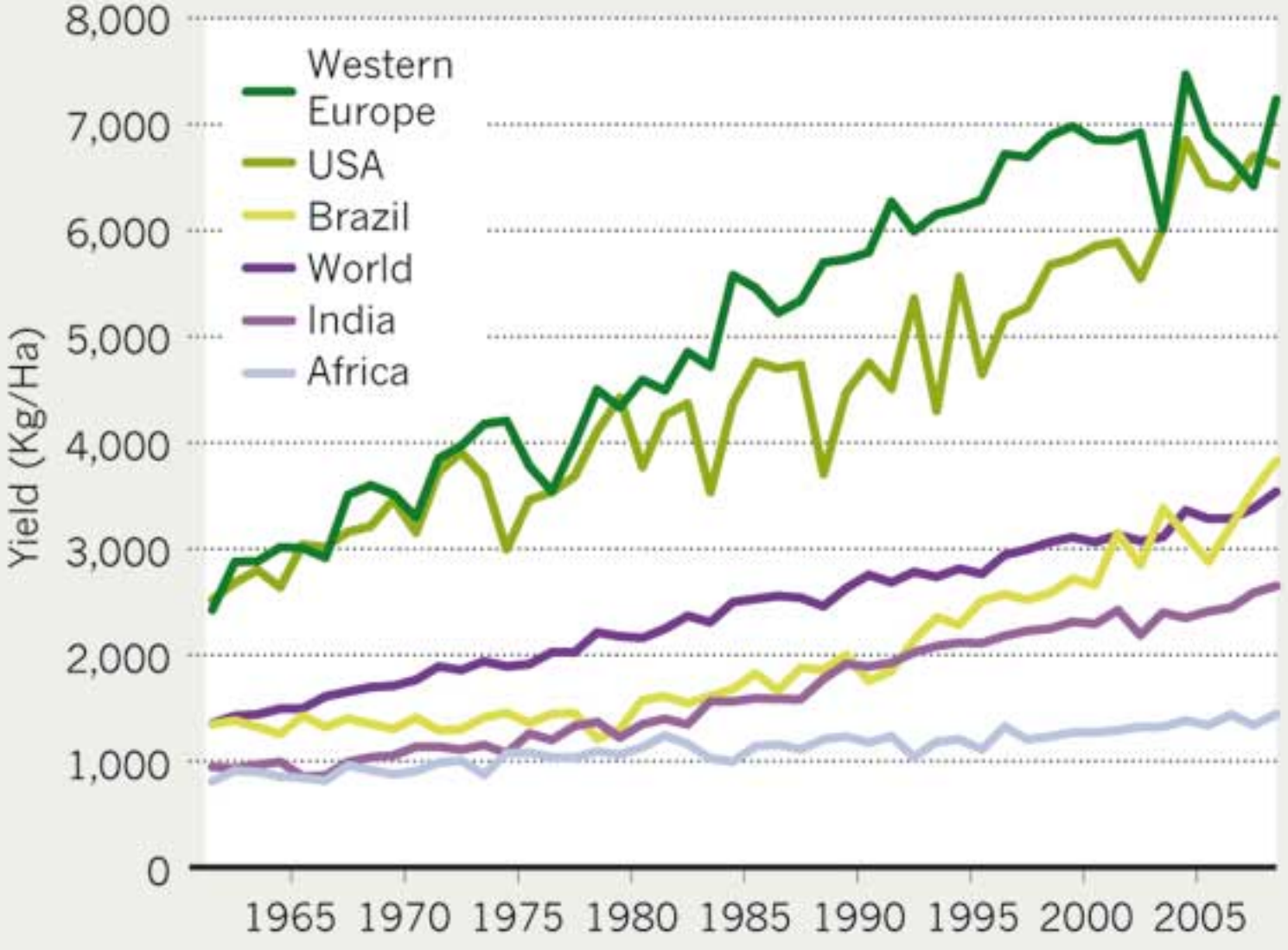
For further information please visit: www.knowledge.allianz.com

World Population Growth-Future Trend

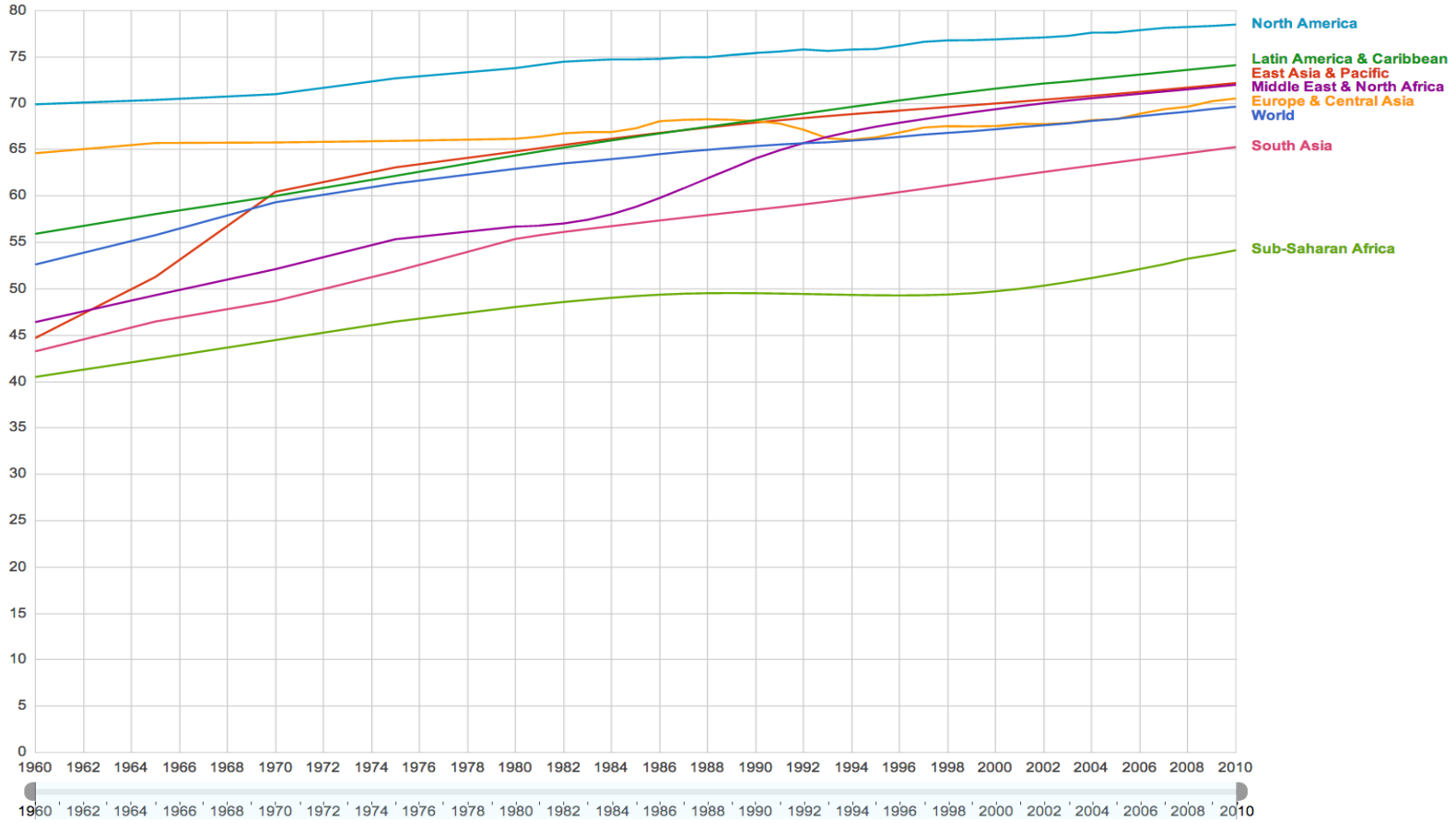
Source - homosapienssaveyourearth.blogspot.com

THE AFRICA LAG

The green revolution largely bypassed Africa, where cereal crop yields have barely improved in 50 years.

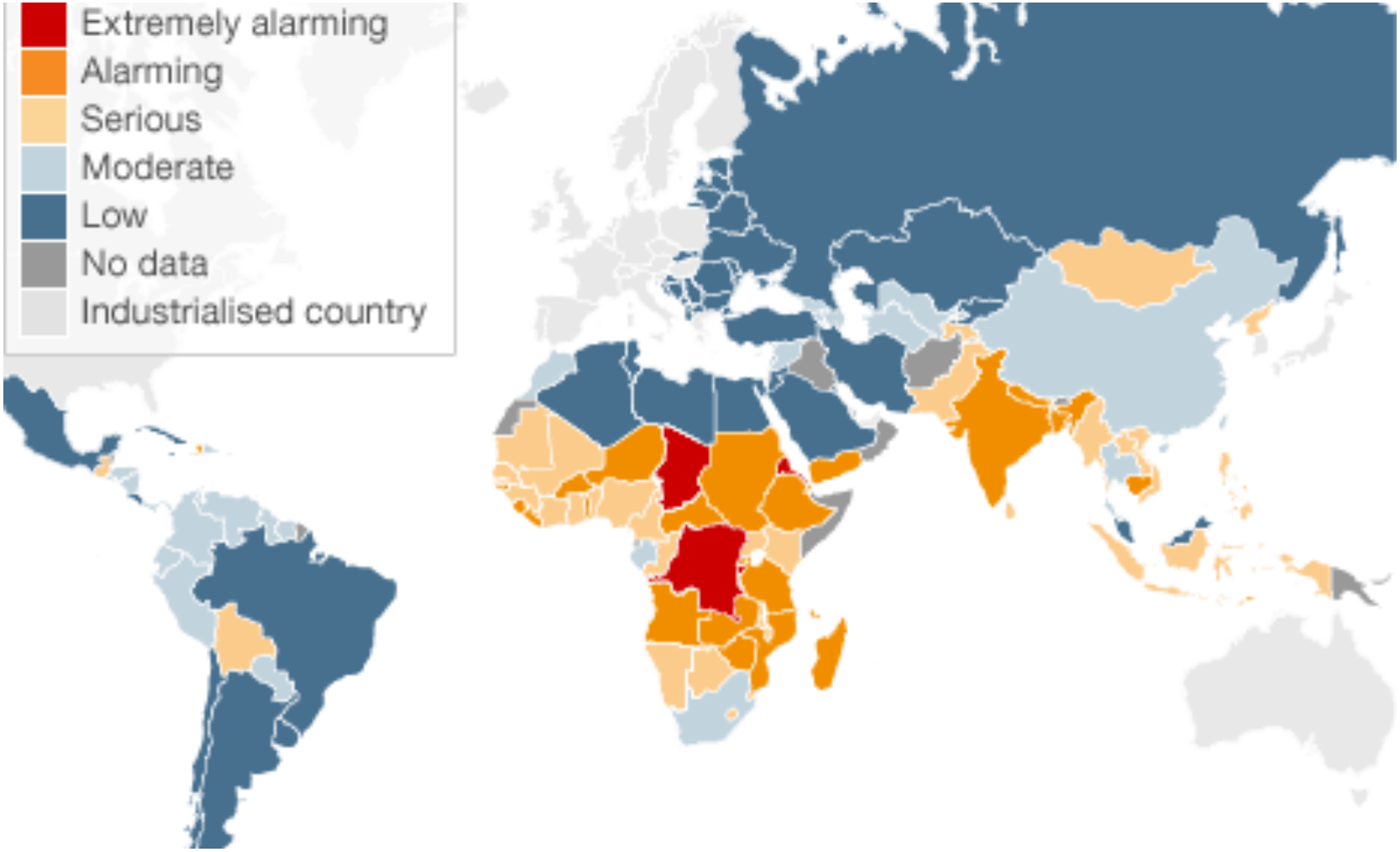


Global life expectancy trend

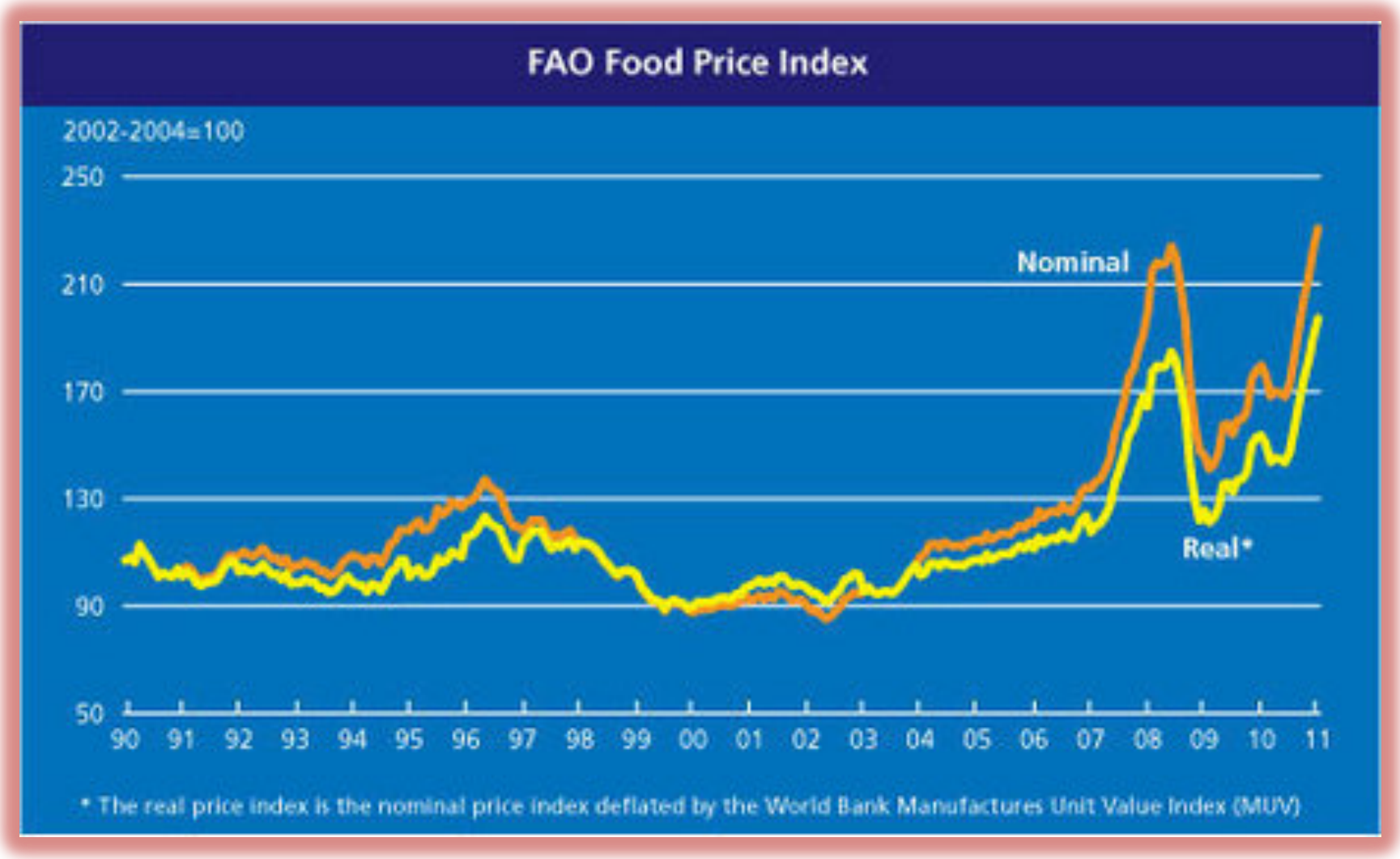


(Source: World Bank, CIA Factbook)

Global Hunger Map



Cost of Food is Going Up



Clicker Question

- How many people die every day due to malnutrition and hunger around the globe?
- a. 300
- b. 3,000
- c. 30,000

Stark Realities…..

- Nearly a billion people go to bed hungry every day
- About 30,000 people, half of them children, die *every day* due to hunger and malnutrition
- Nearly 1.2 billion people live on less than a dollar a day
- 650 Million of the Poorest Live in Rural Areas

"In the next 50 years, mankind will consume as much food as we have consumed since the beginning of agriculture 10,000 years ago - Dr. Norman Borlaug"

Hunger - why?

- Poverty
- Poor governance
- Low agricultural productivity
- Poor infrastructure (roads, market access..)
- Little science R &D
- Conflicts
- Infectious Diseases (Malaria, HIV)
- International markets

Low Productivity of Agriculture in the Developing World

- Poor soils
- Unfavorable environment
- Little or no chemical input
- Small Holdings
- Drought
- **Market Access**
- **Disease, Pests, Weeds**
- **Storage and Transportation**

Food and Agriculture Organization (FAO)

To feed a world of 9 billion people in 2050, without allowing for additional imports of food:

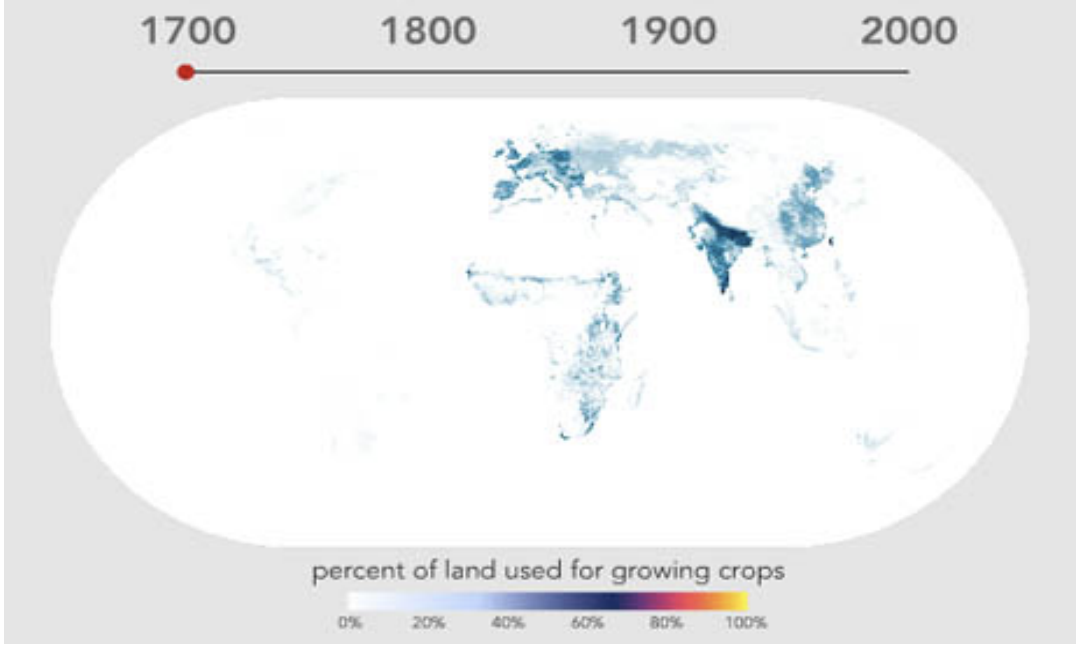
Africa has to increase its food production by 300 percent

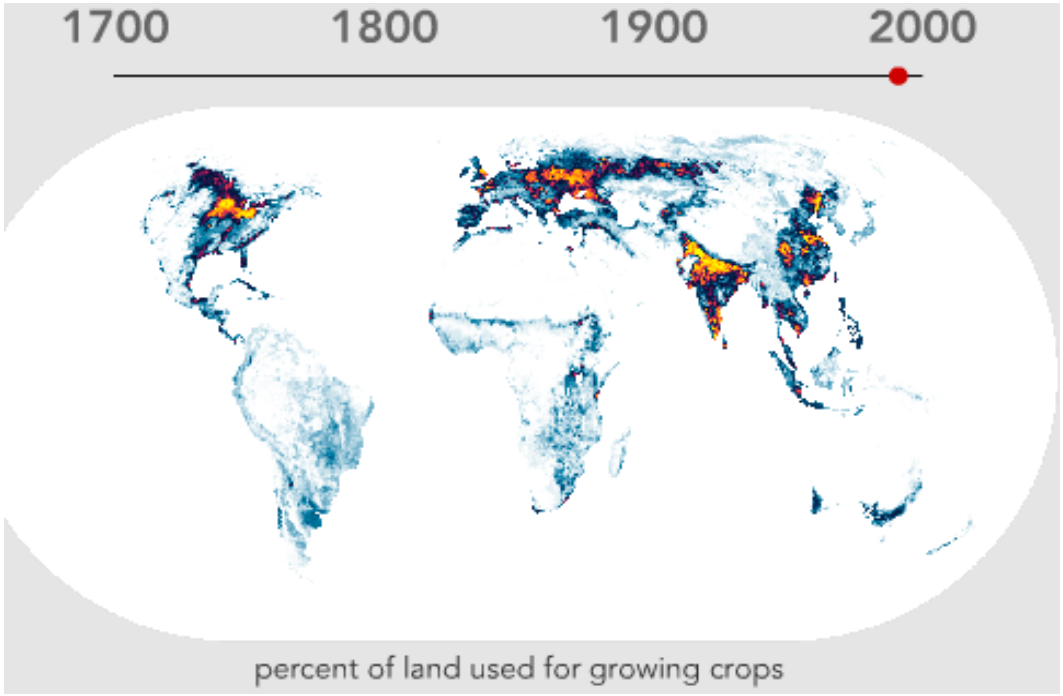
Latin America by 80 percent; and Asia by 70 percent. Even North America must increase food production by 30 percent

•Without an Increase in Farm Productivity, Additional 1.6 Billion Hectares of Arable Land will be Needed by 2050!

Challenges Ahead….

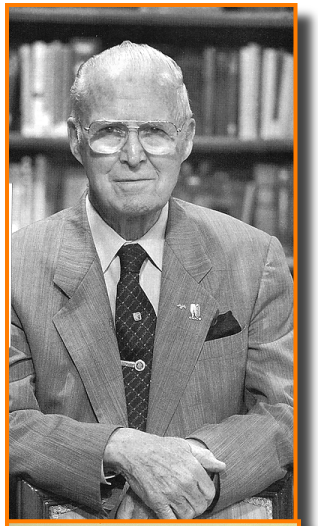
How to produce more food using less land, less water, less chemicals…?

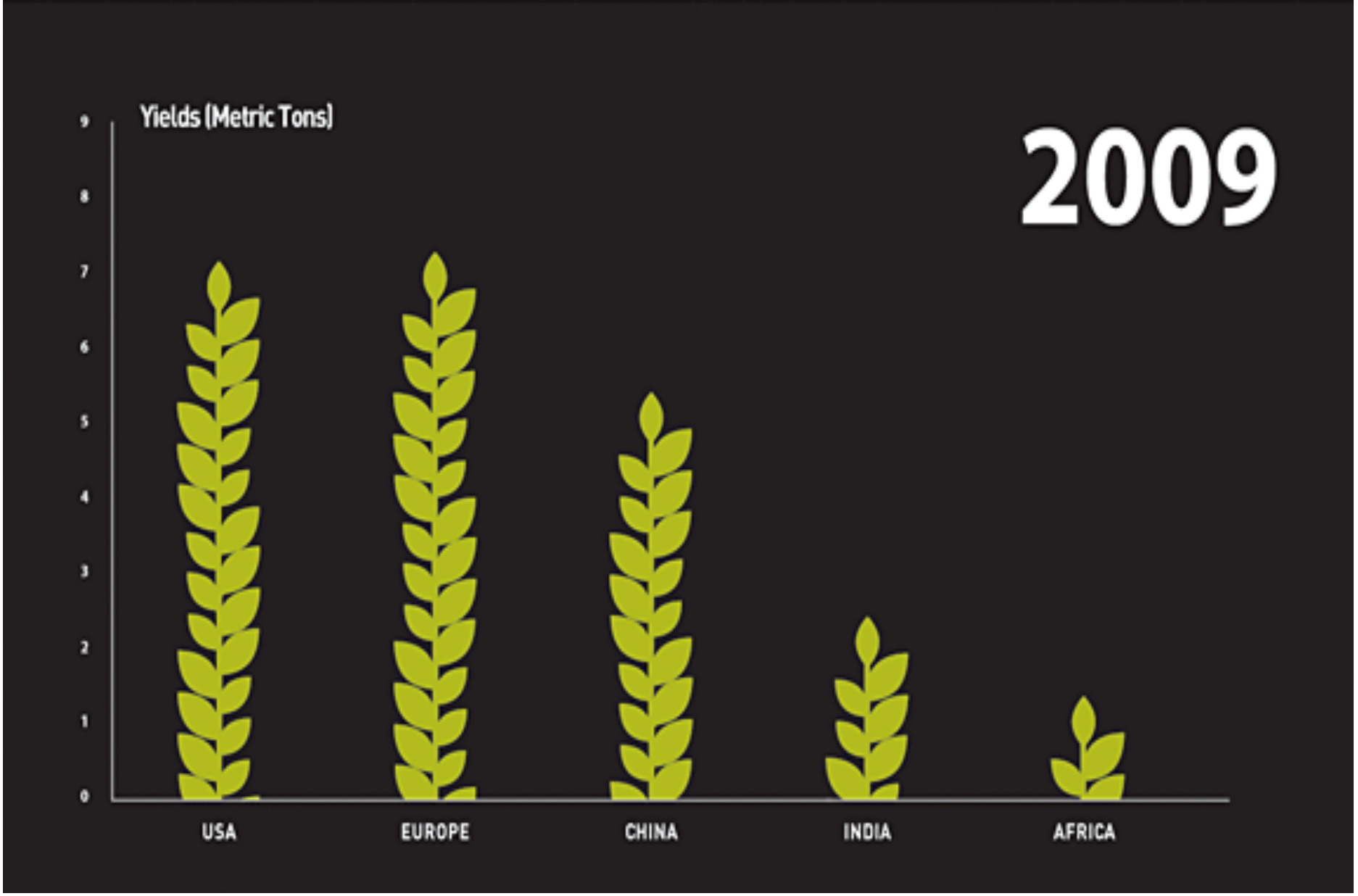

1700
1800
1900
2000
percent of land used for growing crops
0%
20%
40%
60%
80%
100%


1700
1800
1900
2000
percent of land used for growing crops

Innovation in Agriculture

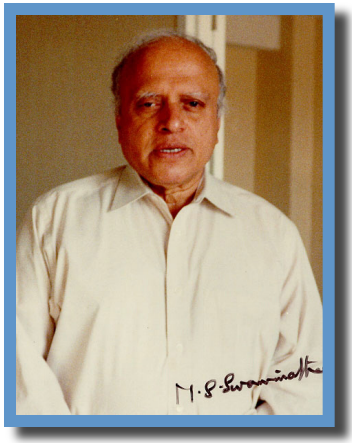
- U.S. Food Production : 252 million tons/year in 1960 to current 700 m. tons/year with 25 million fewer acres
- North American Corn Yields up from 26 bushels/acre (1928) to 180 today
- One North American farmer in 1940 fed 22 people, feeds 150 today.
- 1% of North Americans are Farmers.
- Average 11% of Income on Food



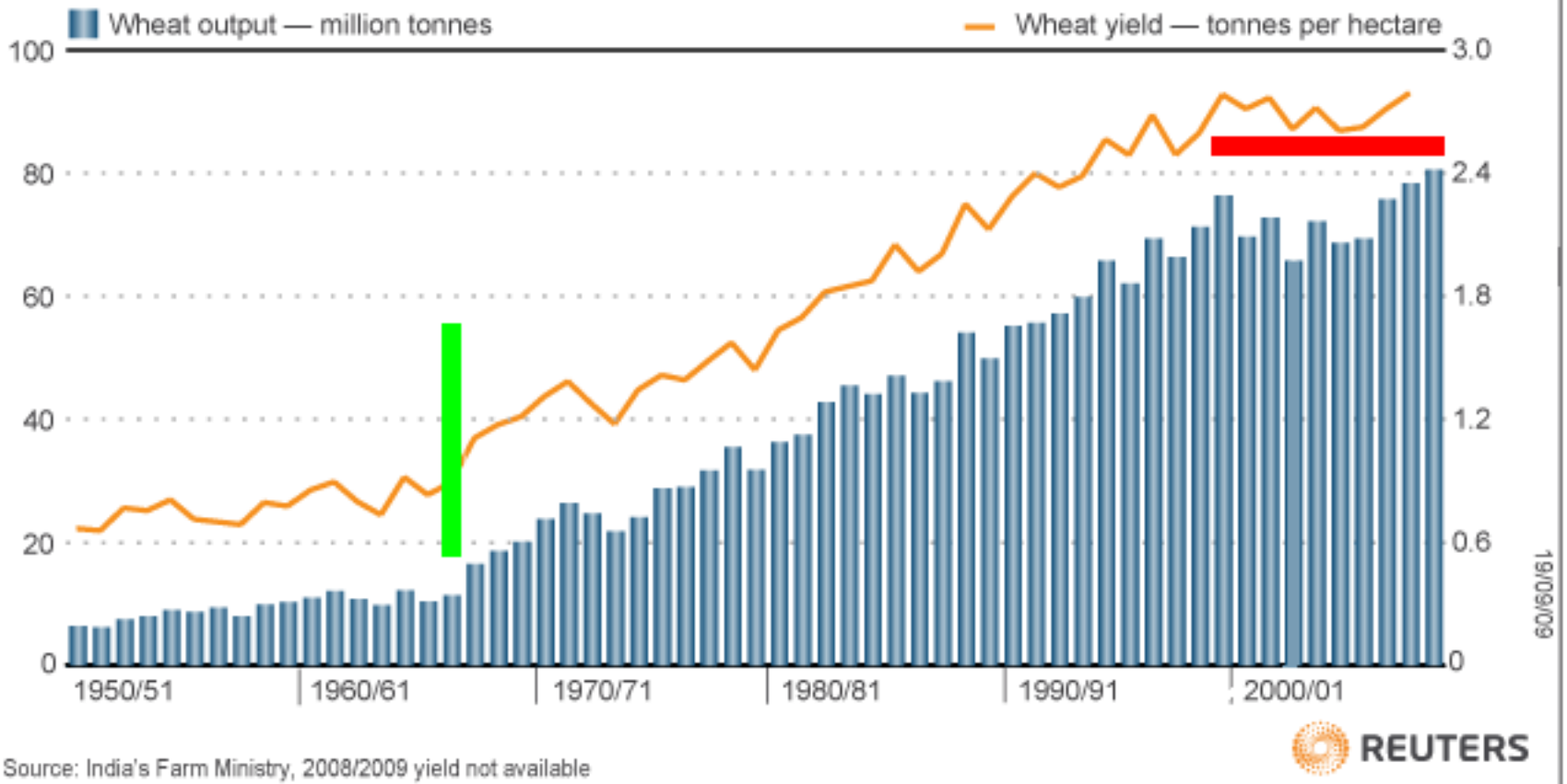

Yields (Metric Tons)
2009
9
8
7
6
5
4
3
2
1
0
USA
EUROPE
CHINA
INDIA
AFRICA

Green Revolution…

- Lifted Billion Plus Out of Poverty
- Undernourished > from 38% to 19% in past 20 years
- Food Consumption per capita has increased everywhere except in Africa - 18% Globally and 28% in LDCs
- **India: Food production from 50 to 225 mil tons in the past 5 decades. Wheat : from 6 to 85 million tons per year!**
- **Less Starvation and Famine**
- **Increased Food Self Sufficiency**



India wheat output and yield



Source: India's Farm Ministry, 2008/2009 yield not available

Current challenges in agriculture

- Higher production
- More nutritious food
- Greater protection

  Against losses due to biotic factors and abiotic stresses, more so due to global climate change.

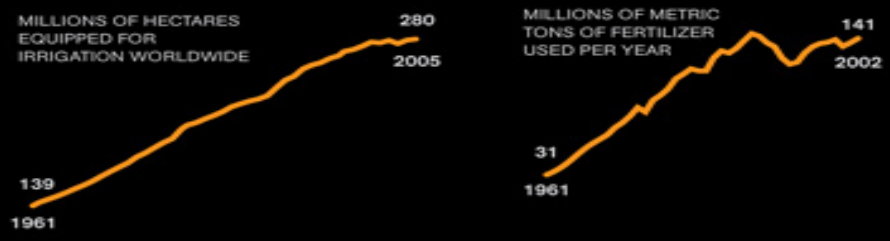
- Cleaner Environment

  To safeguard heath and biodiversity

TO MEET RISING FOOD DEMAND, WE NEED ANOTHER GREEN REVOLUTION, AND WE NEED IT IN HALF THE TIME.

HOW WE DID IT BEFORE

Few agricultural achievements have been as profound as the green revolution, the farming system of irrigation, high-yield varieties, pesticides, and fertilizers that more than doubled yields in Asia during the 1960s and '70s, lowering prices of the staple crops that feed most of the world today. But these breakthroughs have come with ecological costs.



IRRIGATION can double yields compared with those in rain-fed fields. India subsidized more than a million tube wells, resulting in higher production but also aquifer depletion and salinized soils.

DWARF VARIETIES of wheat and rice allowed farmers to u large amounts of fertilizer an water to produce more grain without the plants getting to heavy and falling over.

CHEMICAL PESTICIDES were needed because dense planted fields were more susceptible to insects and diseases. Overuse may resul in 39 million poisonings a yea

SYNTHETIC FERTILIZERS helped the new varieties hit record yields. But they requir huge amounts of fossil fuels to produce and apply, so the cost skyrockets with the pric of oil. Nitrogen fertilizers also pollute aquifers and streams

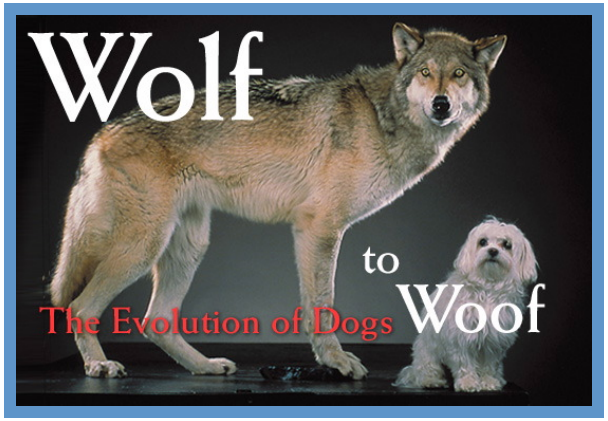
Plant Breeding - Genetic Modification by Farmers and Conventional Breeding

(photos: Dr. Wayne Parrott, Univ of Georgia)

Crop Evolution and Human Civilization

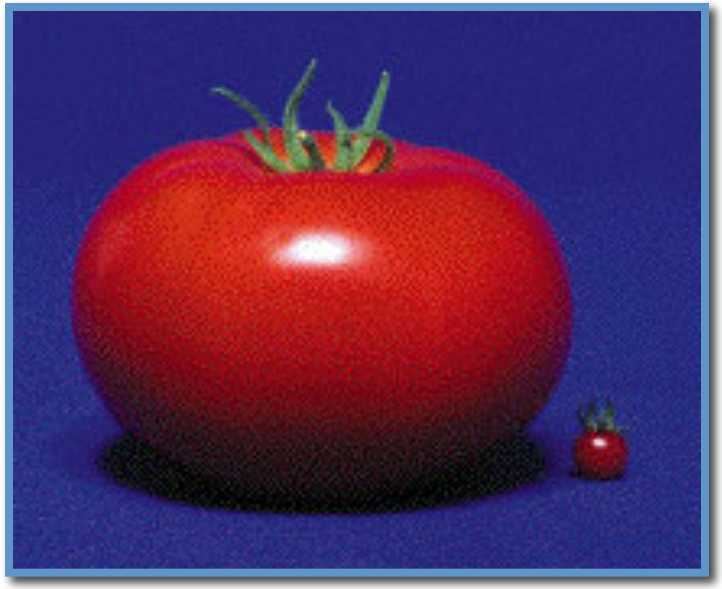
- **Humans have always guided the evolution of crops**
- **A small sample of wild plants were chosen and domesticated**
- **10,000 years of *Selection*.**

- **All crops we grow today were once wild plants. But no crop would survive in the wild any more.**
- **Crops, strains and genes have moved around the globe.**



Improving Our Crop Plants

- **Developing Modern Varieties of Crops**
  - Hybridization
    - Crosses with Wild Relatives
    - Hybrids
  - Mutation
    - Irradiation
    - Chemicals
  - Cell Culture
    - Embryo Rescue
    - Somaclonal variation



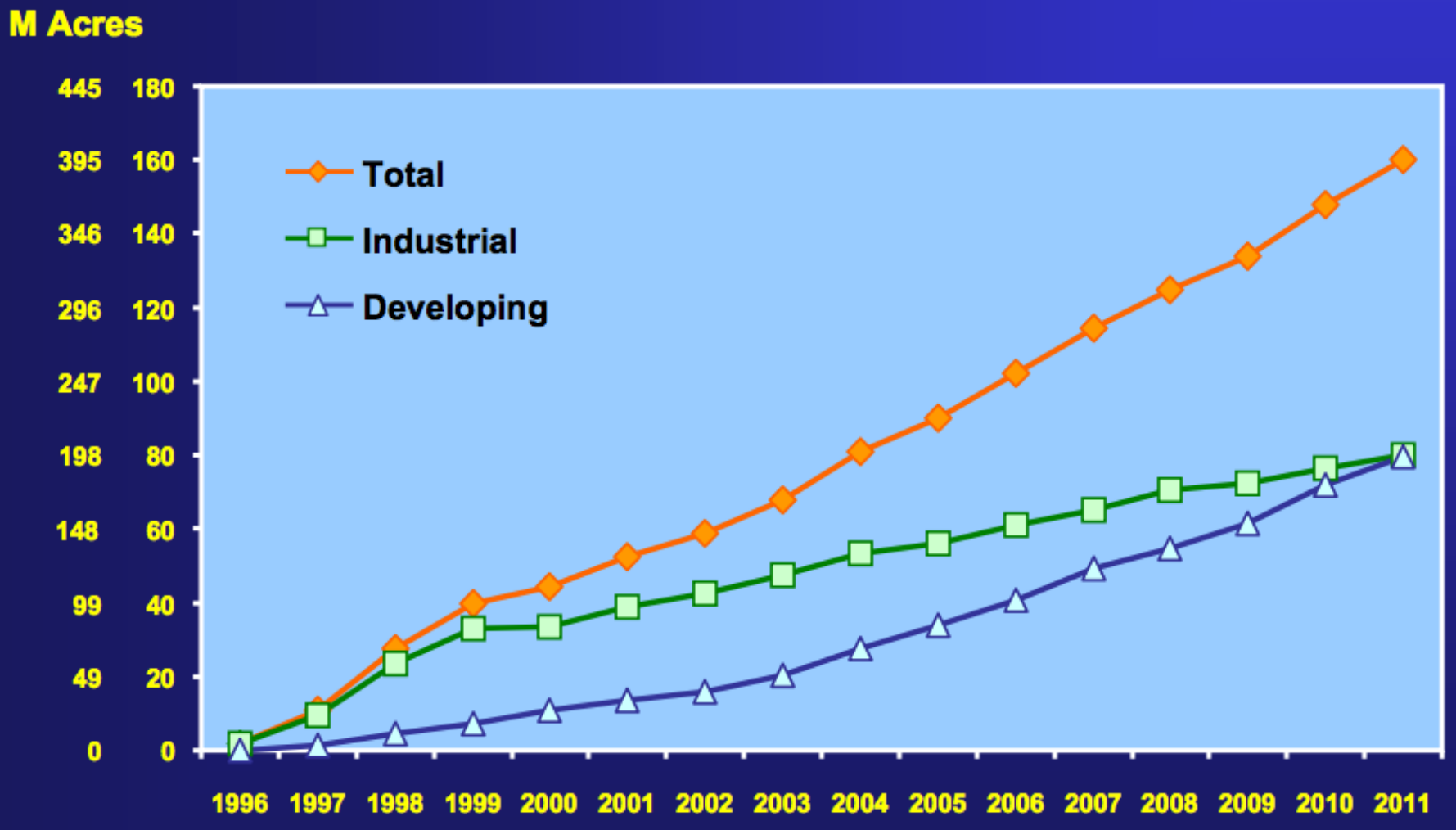
Modern Genetic Modification

Inserting one or few genes to achieve desired traits.

Transfer of Genes into Crop Plants

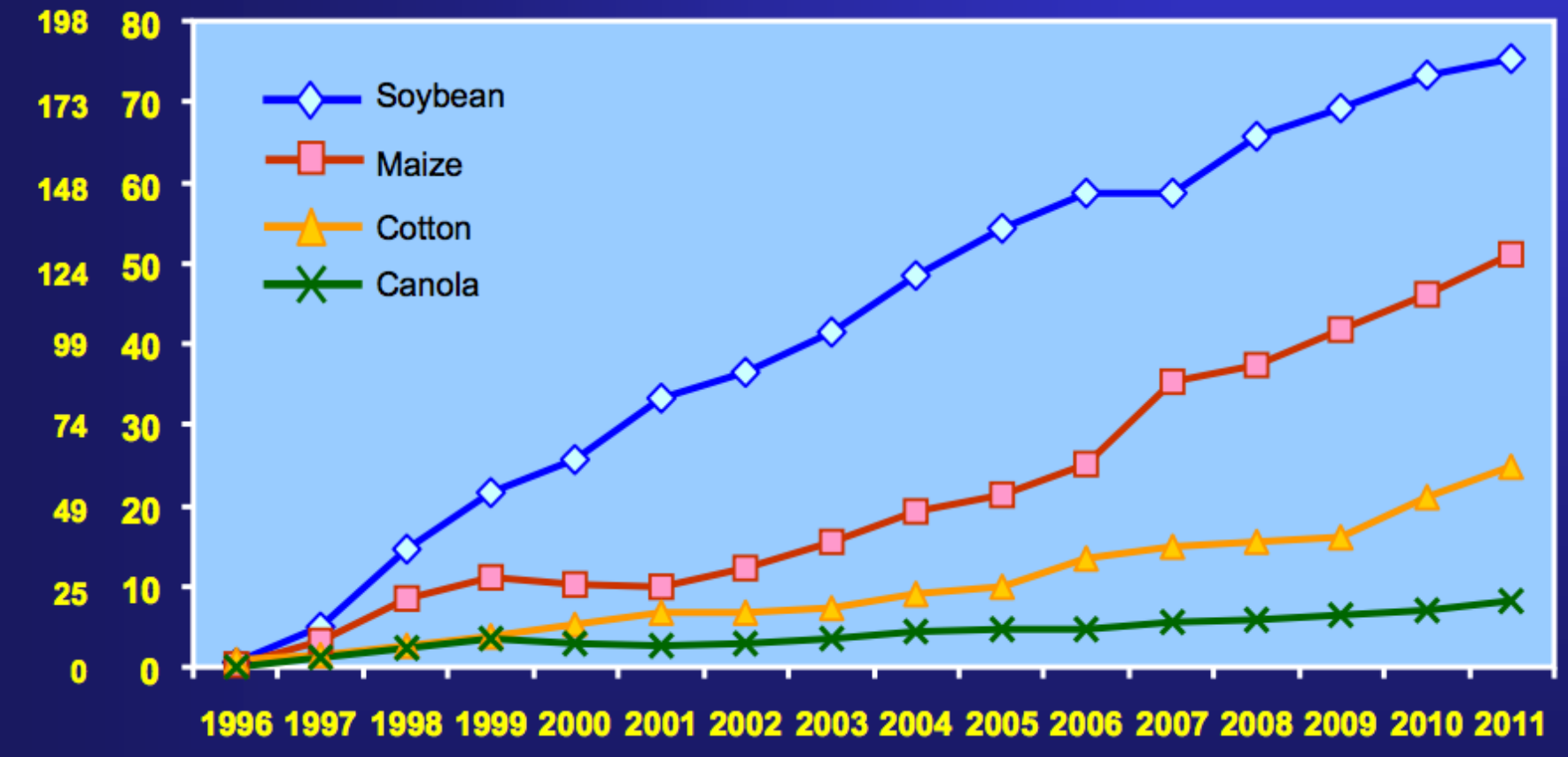
- Relatively Precise and Predictable
- Changes are Subtle
- Allows Flexibility
- Expeditious

Global Area of Biotech Crops, 1996 to 2011: Industrial and Developing Countries (M Has, M Acres)



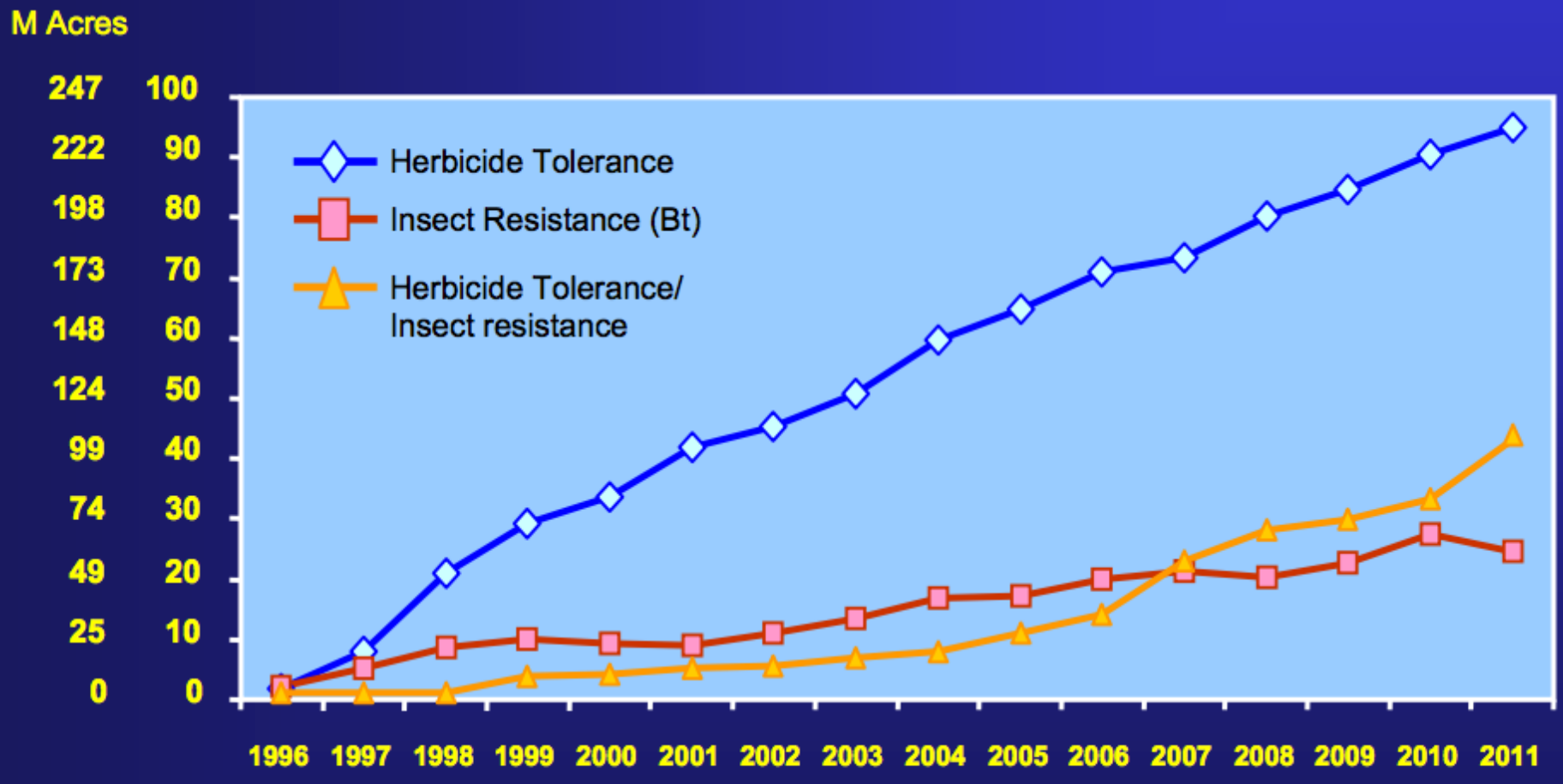
Source: Clive James, 2012

Global Area of Biotech Crops, 1996 to 2011: By Crop (Million Hectares, Million Acres)



Source: Clive James, 2012

Global Area of Biotech Crops, 1996 to 2011: By Trait (Million Hectares, Million Acres)



Source: Clive James, 2012

Biotech Crop Countries and Mega-Countries, 2011

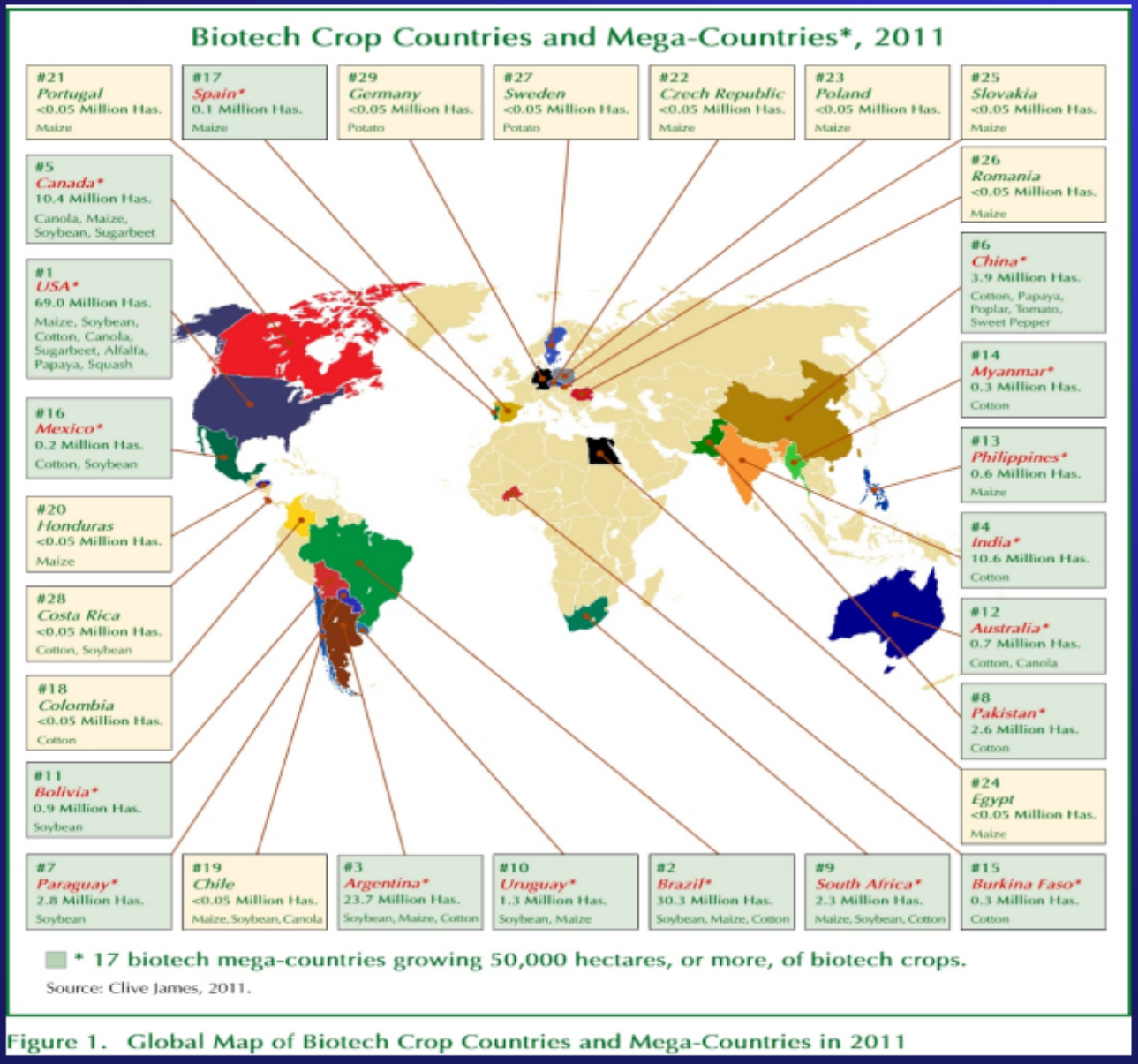
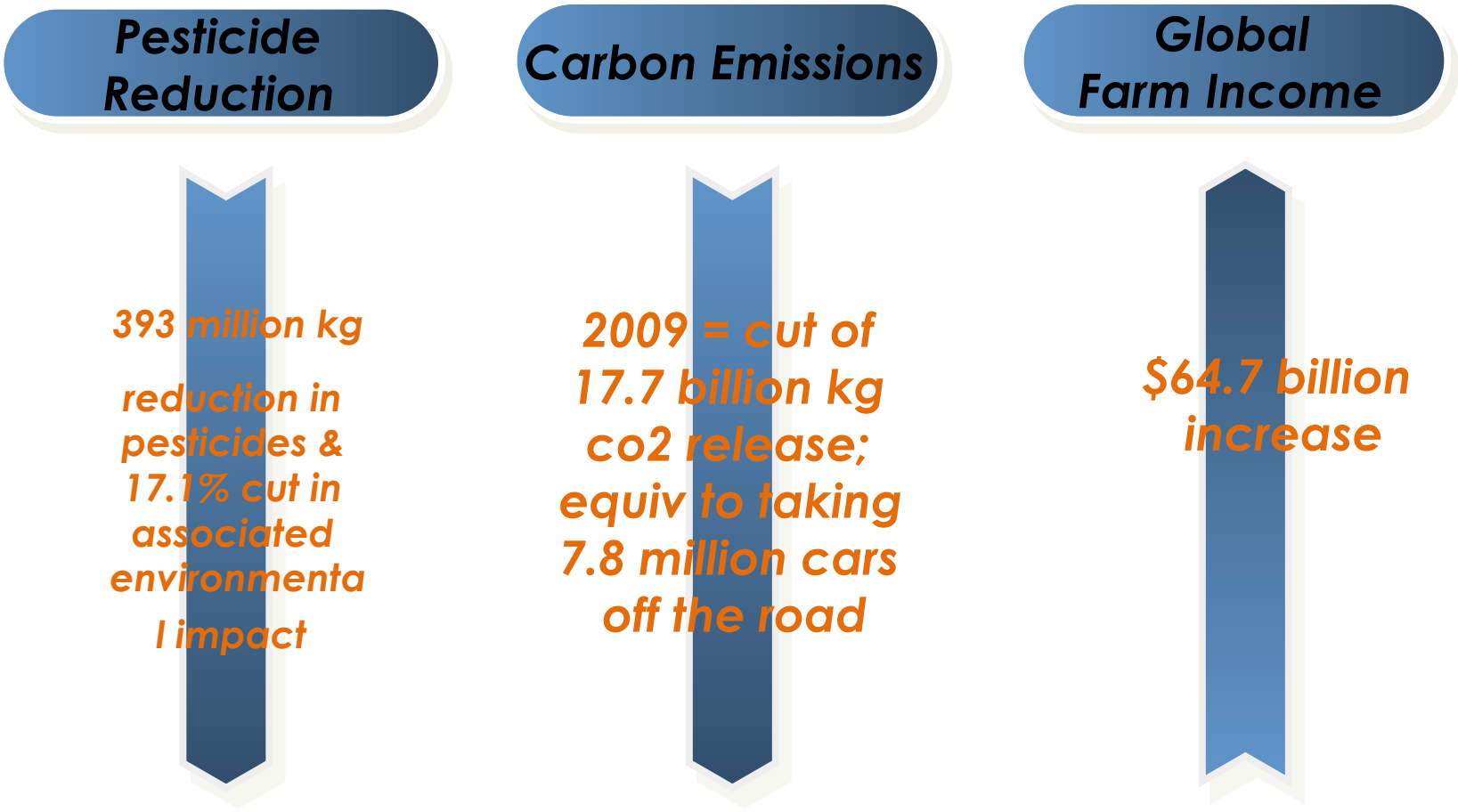


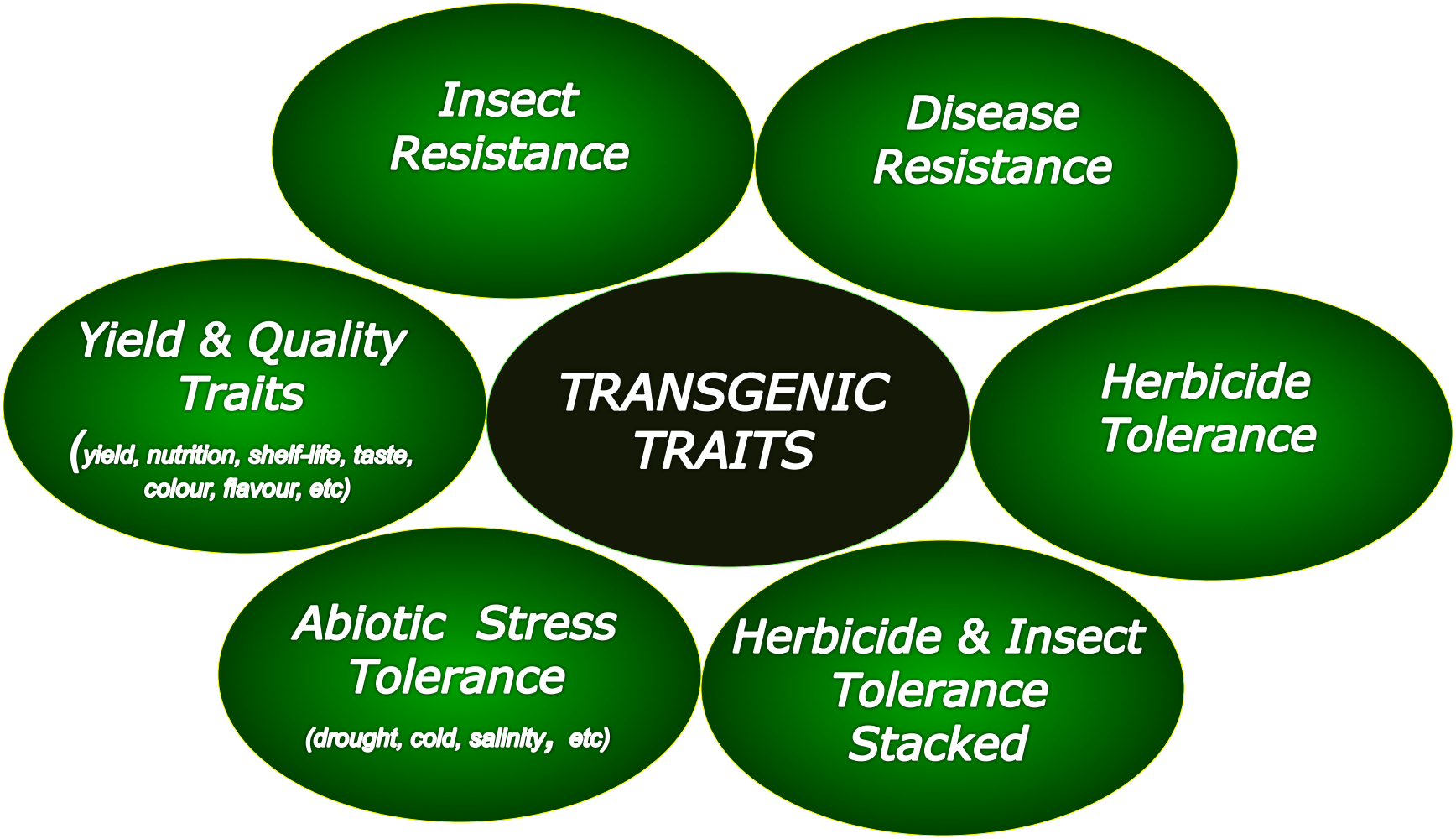
Figure 1. Global Map of Biotech Crop Countries and Mega-Countries in 2011

Environmental and Economic Impact



After 14 years of commercialization, biotech crops have yielded a net increase in farm income while significantly

GM CROP TRAITS



How Can Biotechnology Add Value to Global Agriculture?

- Environmental Impact - Decreased use of pesticides
- Reduce losses from pests and diseases
- Improve nutrient efficiency
- Improve productivity

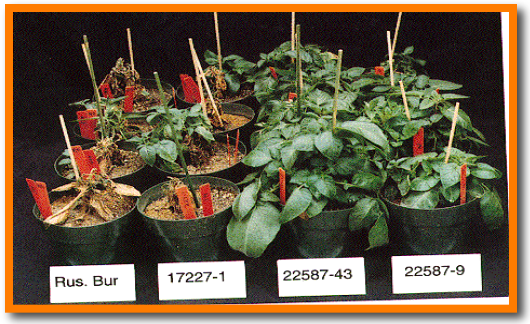
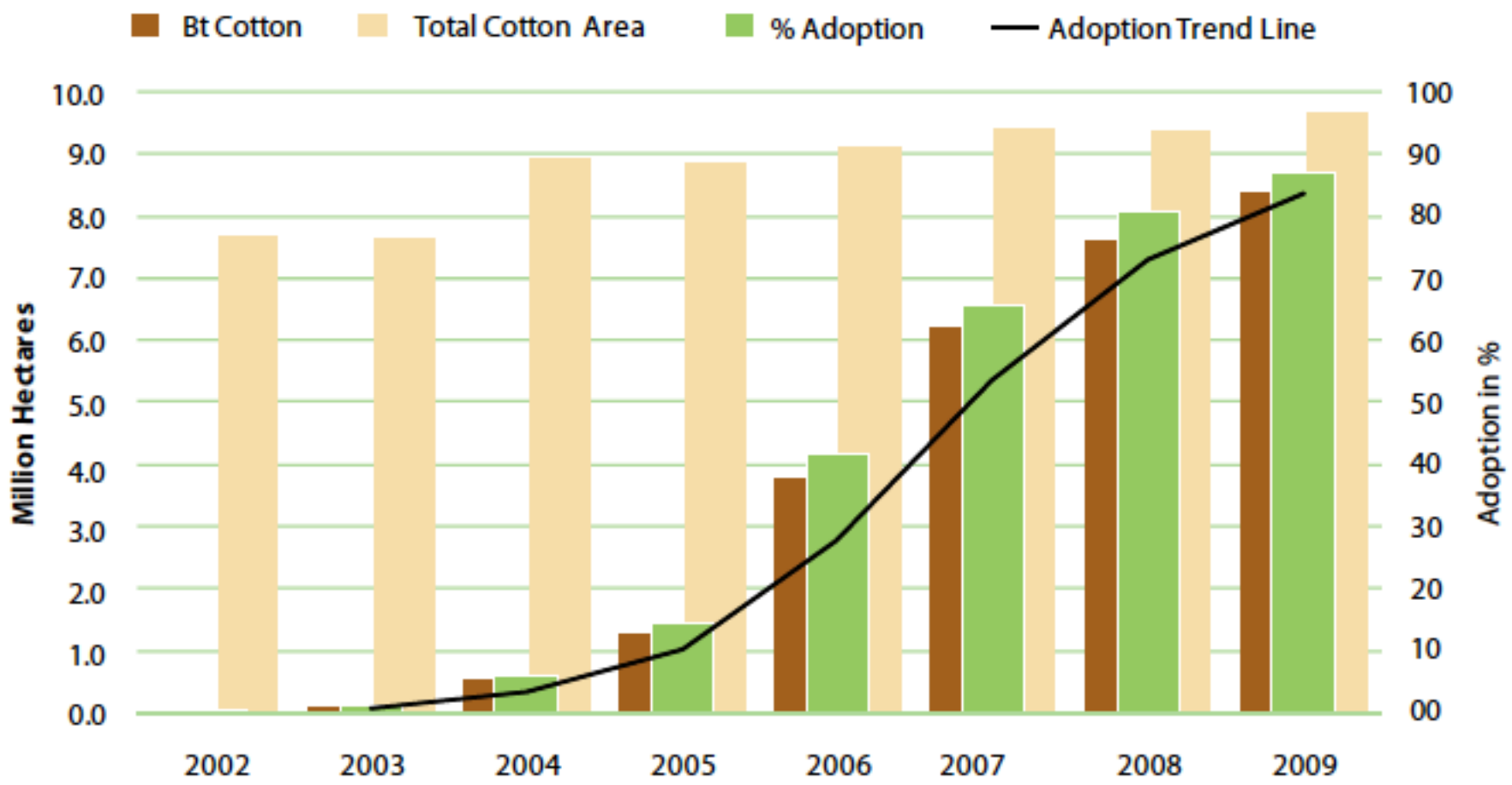
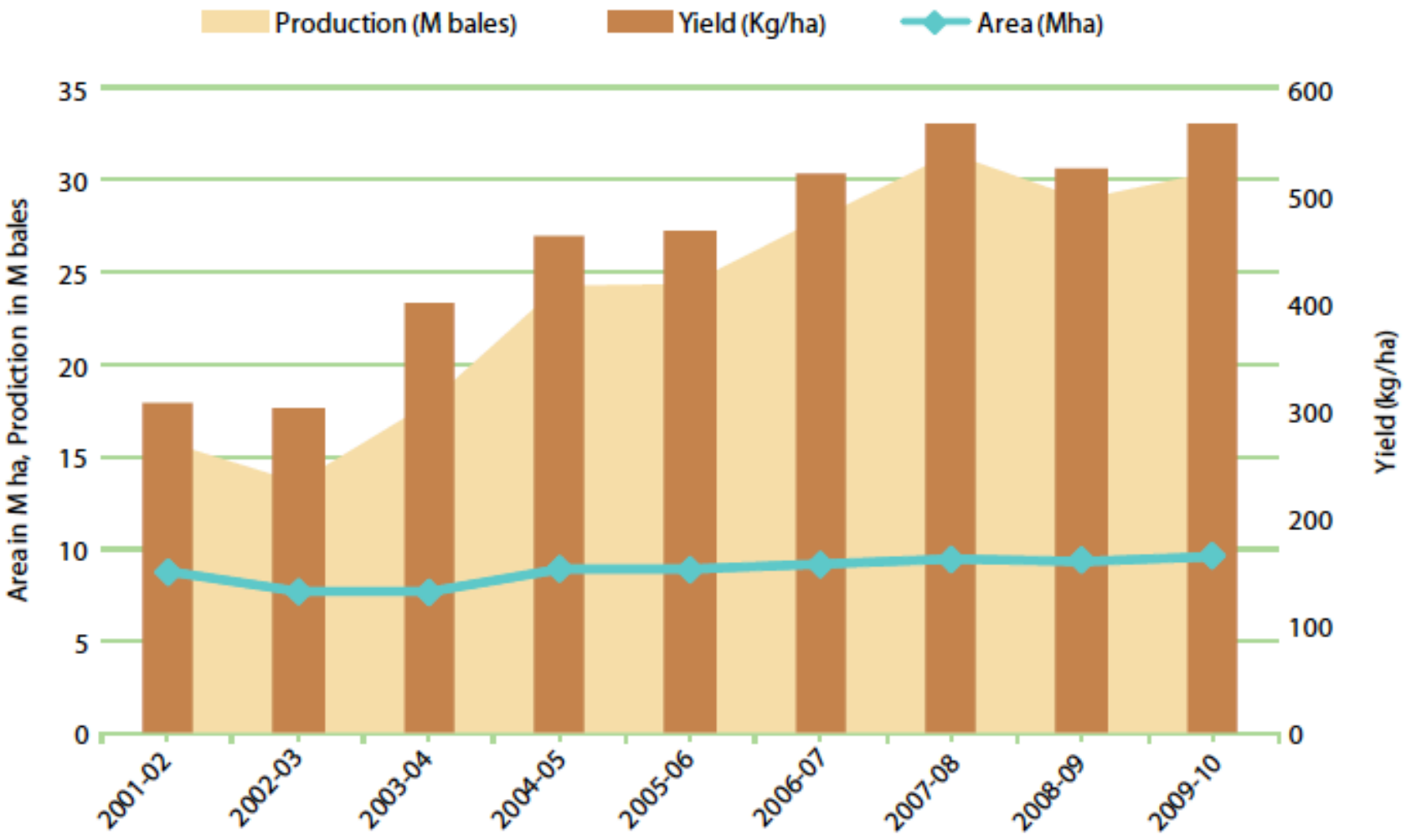


Figure 1. Adoption of Bt cotton in India for the eight year period, 2002 to 2009



Source: Compiled by ISAAA, 2009.

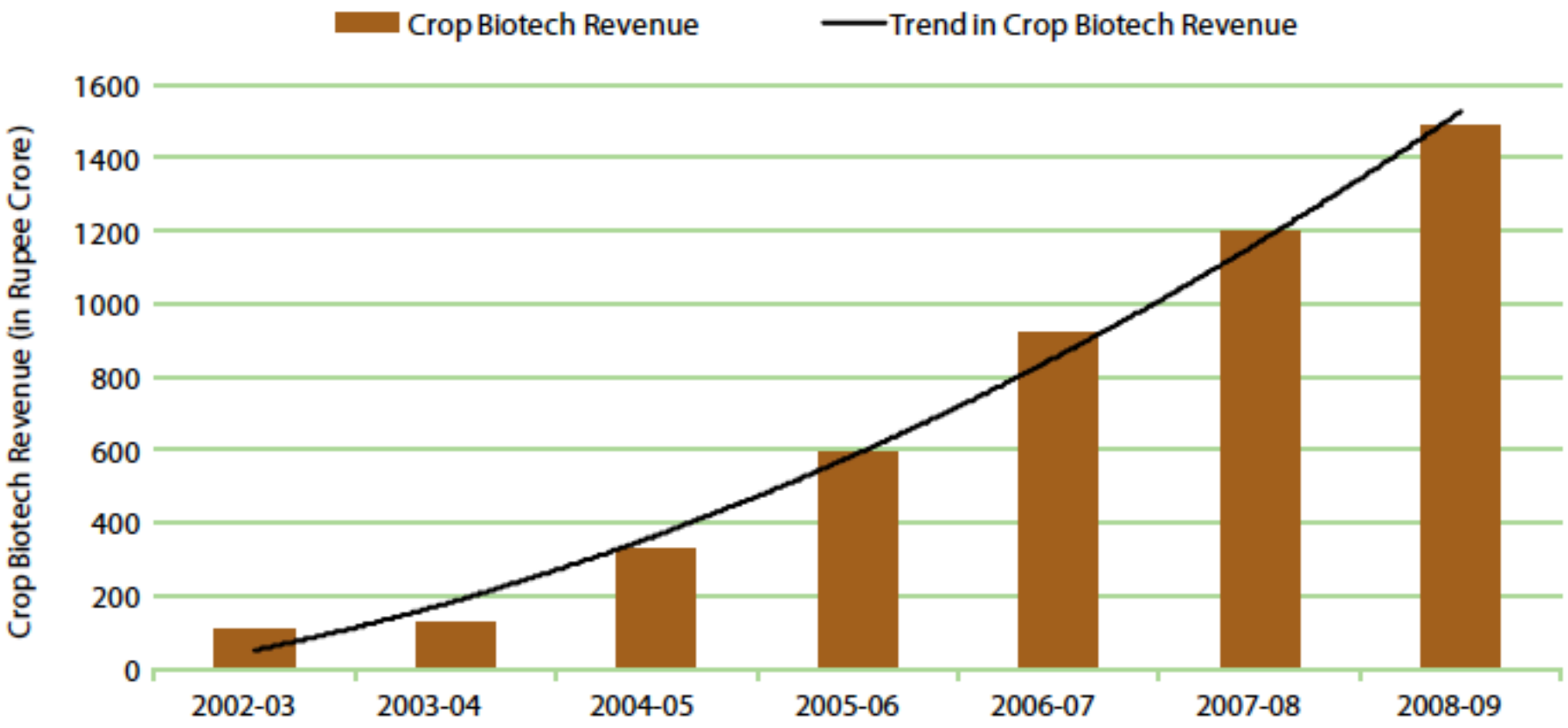
Figure 5. Cotton hectarage, production and yield in India, 2001 to 2009



1 bale = 170 kg

Source: Cotton Advisory Board, 2009.

Figure 7. Bt cotton hybrids market in India (in rupee crore), 2002 to 2008



(1 Crore = 10 Million Rupees)

Source: BioSpectrum India, 2009.

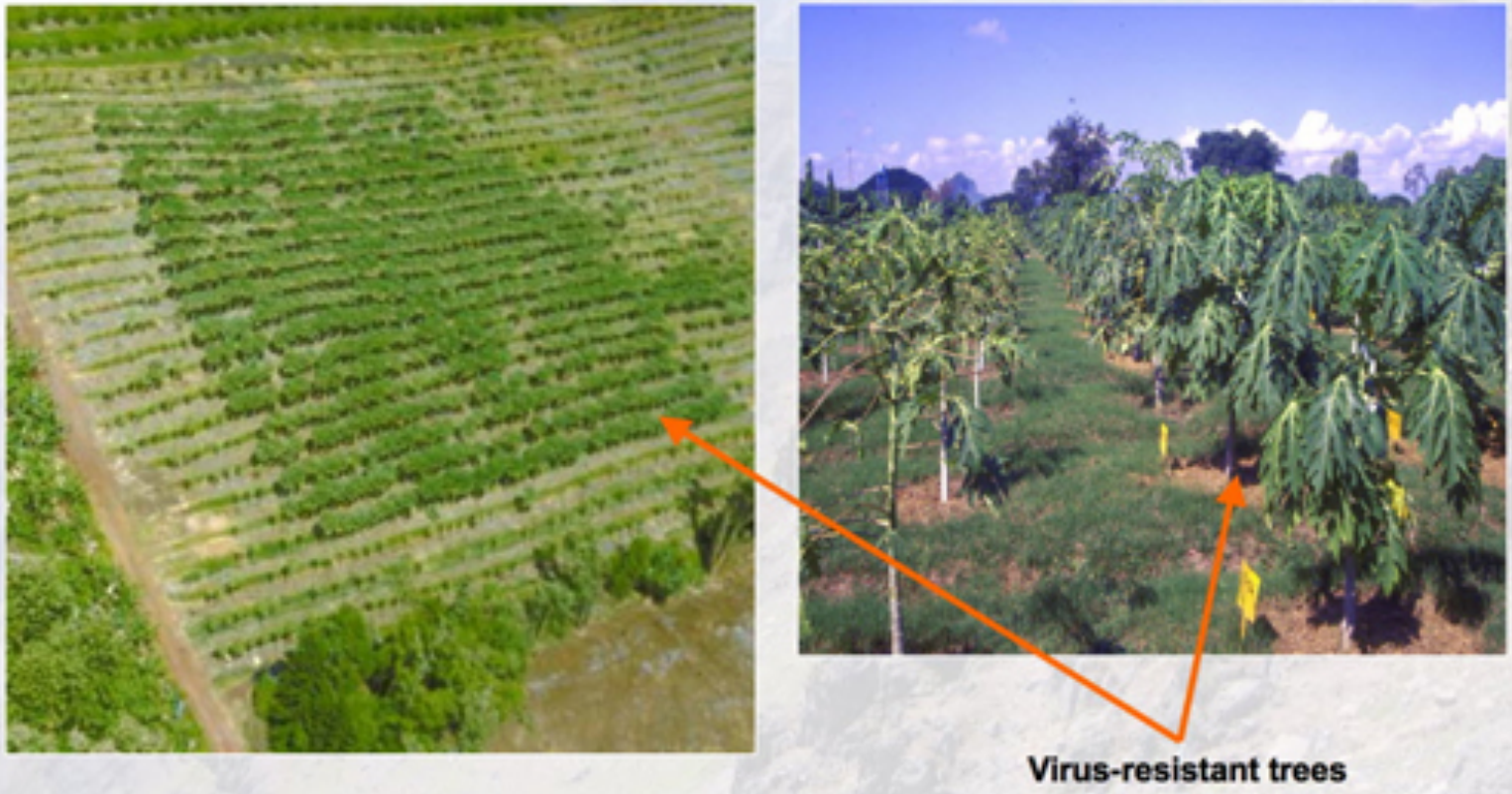
‘GM’ Eggplant in India – Not Approved!

Bt Corn

(Low Mycotoxin)

Virus-resistant papaya

Saved the Hawaiian industry in the mid-1990s
90% of crop today



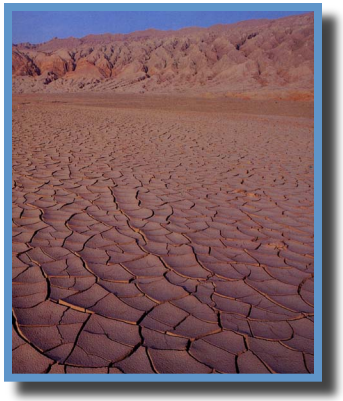
Provided by Denis Gonsalves, formerly of Cornell University

Arcadia Biosciences develops canola that uses 50% less nitrogen fertilizer

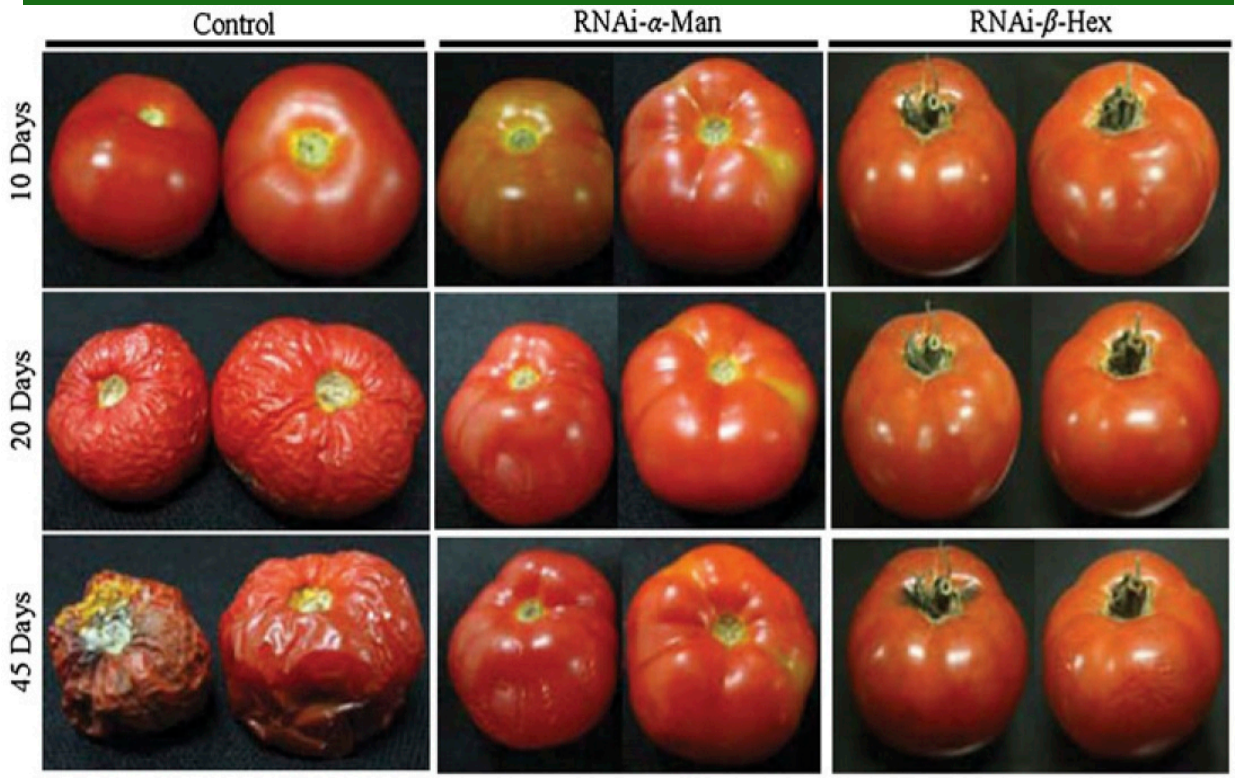
SOURCE: http://archives.foodsafety.ksu.edu/agnet/2007/4-2007/agnet_april_10.htm#story0

Benefits of Biotechnology…..

- Post Harvest Quality - prolong shelf life of fruits, vegetables and flowers
- Extend crop area and season
- Stress tolerance - drought, acidity, salinity, heat, flooding



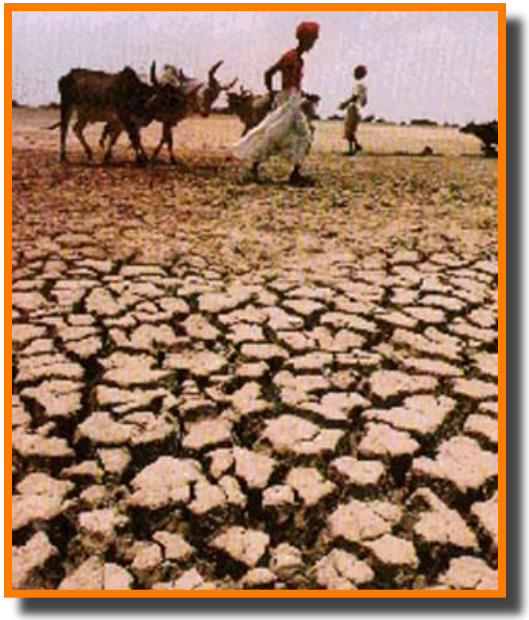
Engineered tomatoes have ~30 day extension of shelf



SOURCE: Meli, V.S., Ghosh, S., Prabha, T.N., Chakraborty, N., Chakraborty, S., and Datta, A. 2010. Enhancement of fruit shelf life by suppressing N-glycan processing enzymes. Proceedings of the National Academy of Sciences USA, doi/10.1073/pnas.0909329107.

Drought

- **Extended period of deficiency in water supply**
- **Major constraint to farming**
- **Spurred Green Revolution in India?**



Drought Tolerant Corn

Photo: Monsanto Co.

Freeze Tolerant Biotech *Eucalyptus*

Results from first winter in South Carolina

Results from second winter in Alabama

Field results indicate freezing tolerance to ~16°F (- 8° to - 9°C)

Source: www.arborgen.us

Enhancing Food and Agriculture

- More Nutritious Food
- Healthy Produce. Low Toxins
- Pharmaceutical Proteins
- Clean Up Environment
- Biofuel - Ethanol, biodiesel
- Industrial Products
- Value-Added Products

Golden Rice

- Milled rice has no beta-carotene
- Vitamin A deficiency - 200 million children and woman
- About 500,000 children go blind (60 every hour!)
- 2 million children die each year
- Golden Rice may provide one of the many solutions

Engineered corn:
169-fold increase in Vitamin A precursor
6-fold increase in Vitamin C
2-fold increase in folate

SOURCE: Naqvi et al. 2009. Transgenic multivitamin corn through biofortification of endosperm with three vitamins representing three distinct metabolic pathways. Proceedings of the National Academy of Sciences USA, doi: 10.1073/pnas. 0901412106.

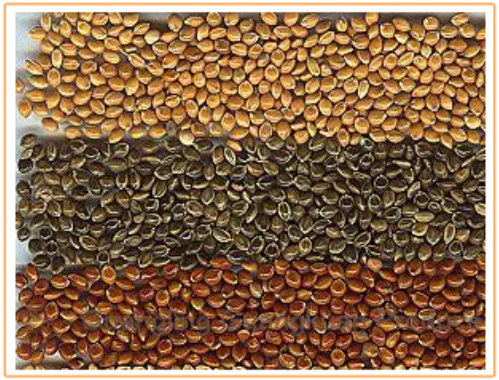
Herbicide Tolerance

Simplifies non directed applications

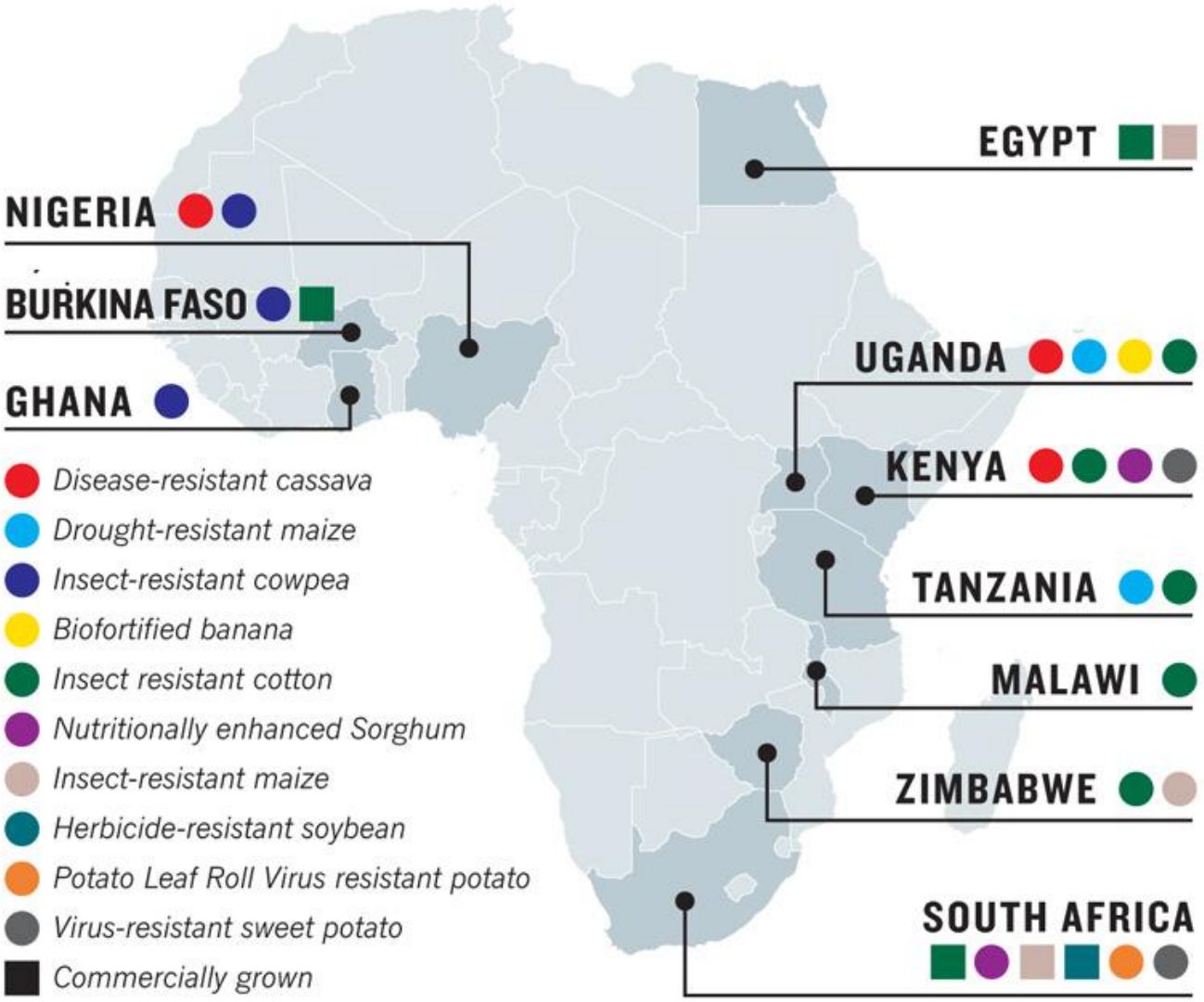

Striga = witch weed


LOCAL CHECK
H513
IR MAIZE
SINGLE CROSS 1

Crops Feeding the Developing World



GM Crops in Africa



(From Nature, Oct. 1 2010

Sweetpotato

- Fourth largest crop in the developing world
- Excellent source of calories, vitamins and minerals
- **Grown by resource-poor farmers**
- **Very hardy**

Resistance to Virus and Weevil
Enhancement of Nutritional Protein

Cowpea

Healthy Cassava

Virus-infected Cassava

Black Sigatoka Disease of Banana

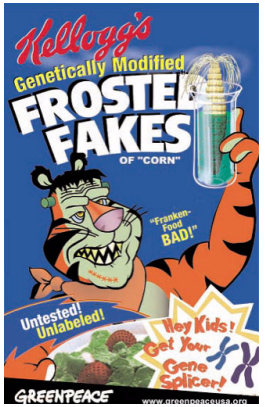
Vegetables

Fruits

Blue Rose!

Constraints to Biotech in the Developing World

- Economic
- Policy
- Technical Capacity
- Trade Backlash
- Intellectual Property
- Limited private sector



Why Europe Dislikes Biotech Crops?

- Poorly understood science
- Lack of reliable information
- Mistrust of regulators
- Absence of consumer benefits
- Negative media opinion
- Opposition by interest groups
- Mistrust of the globalization and multinational corporations
- 'Not safe or natural'
- Environmental worries

How Can Biotech Help Global Agriculture?

- Improve Food and Nutritional Security
- Increase Crop Productivity
- Enhance Production Efficiency
- Reduce Crop Damage& Food Loss
- Promote Sustainable Agriculture
- Reduce Environmental Impact
- Empower the Rural Sector through Income Generation
- Reduce Economic Inequity

Thank you!

prakash@mytu.tuskegee.edu