
GM Crops –
Their Role in Less
Developed Countries
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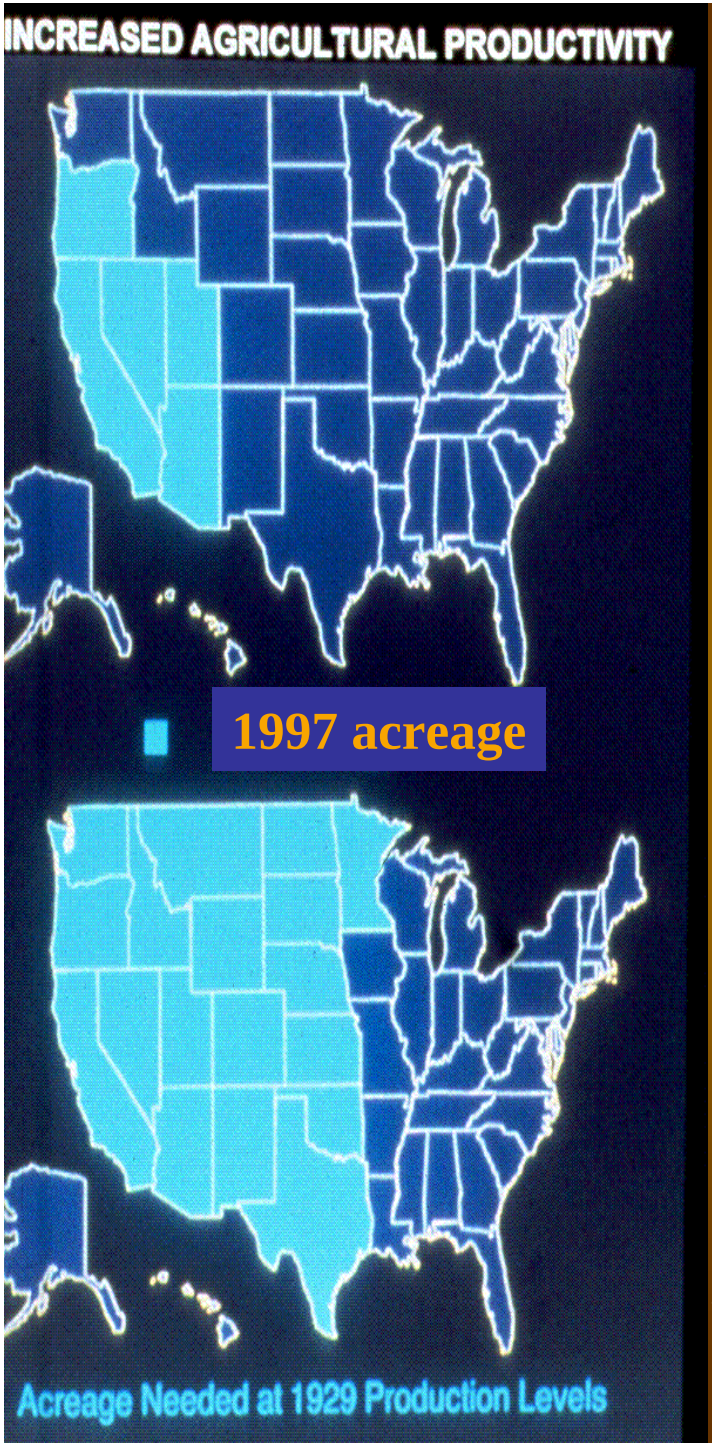
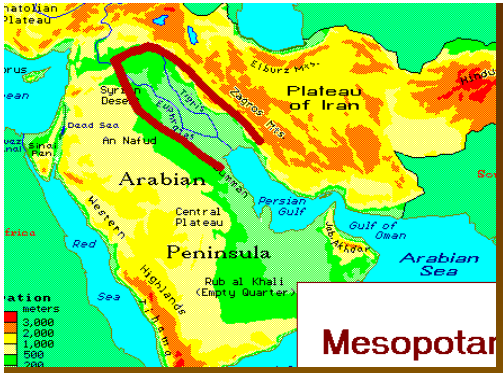


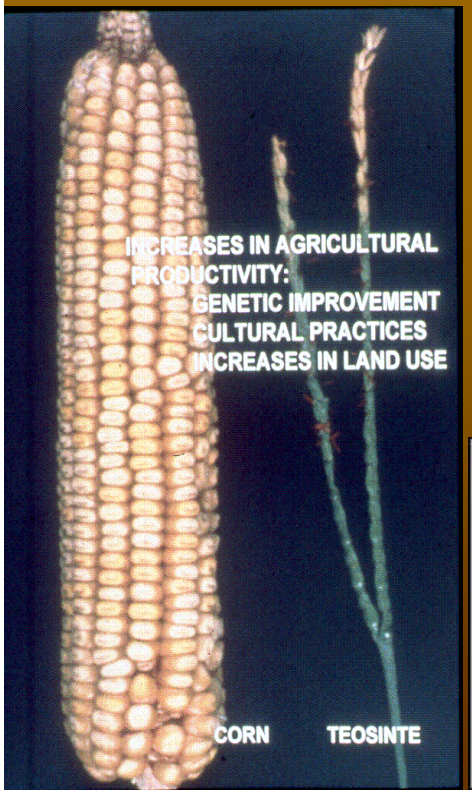
Reality check

- To feed 9 billion by 2050, Africa has to increase its food production by 300% Latin America by 80%; and Asia by 70%. North America by 30%
- 17% of land under cultivation degraded by human activity 1945 to 1990. Ag land shrinks by 20,000 ha yearly. (World Bank)
- Domestic Food Production Provides for 97% of Consumption in the Low Income Group
- Without yield increase land use will double by 2050. Without greater productivity China/India will need 4X land area
- Latin America: greatest yield increase had lower land use (less deforestation)
- High yield “land sparing” better than “wildlife”-friendly inefficient land use farming
- We Must Produce More Food with Less Land, Less Water, Less Chemicals…

Green, Royal Soc. Bird Protection African Society Ornithology 2005)

Agriculture: A history of Technology





8,000 BC	Cultivation
19thC	Selective Cross breeding
Ea 20th C	Cell culture
Md 20th C	Somaclonal variation
1930s	Embryo rescue
1940s	Mutagenesis and selection
1950s	Anther culture
1970s	Recombinant DNA
1980	Marker assisted selection
1990s	---omics - Bioinformatics
2000s	Systems Biology
21st C	Epigenetics/RNAi/Paramutation
	Adaptive technology/transgenomics

Biotech Crops –"process" regulation

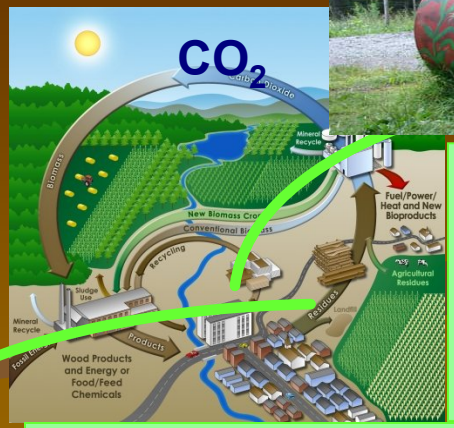
- Commercialization: 7 to 10 years -at least 9 review stages
- Biotech crops and foods more thoroughly tested than conventional varieties ("assumed" to be safe)- One biotech soybean subjected to 1,800 separate analyses
- 23 feeding studies - dairy, beef, poultry, soy/corn equivalent in composition, digestibility and feeding value to non-GM. Clarke et al 2000
- Product description (7 items) - Substantial equivalence with parent variety - Molecular characterization (17)
- Toxicity studies (as necessary) (5) - Antibiotic resistance marker genes (4) - Nutritional content (7+)- Allergenicity potential - Anti-nutritional effects - Protein digestibility
- Environmental aspects (5 items)- Ecological impact (5 items)

Recent studies

Wheat (Baker 2006), Potato (Catchpole 2005)

Transcriptomic and Metabolomic studies show greater variation between conventional bred cultivars and even growth locations than between GM and parental variety (except of course for the intended modification!) - differences between sites were generally greater than differences between lines

Plant Biotechnology Generations



Renewable Resources

$5 B to farmer profits by 2025

Value

Plants as Factories

Pharmaceuticals/ Industrial products
(Ventria – Rice Lactoferin Lysozyme Peru 30% Less Diarrhea, Quicker recovery 3/6 days, 1/3 less recurrence

Quality Traits - ($210B by 2010)

Shelf life –

Improved Nutrition –Improved Functionality

Macro: protein, oils, carbs, fibre

Micro: Vitamins, minerals, Phytochemicals – Antioxidants

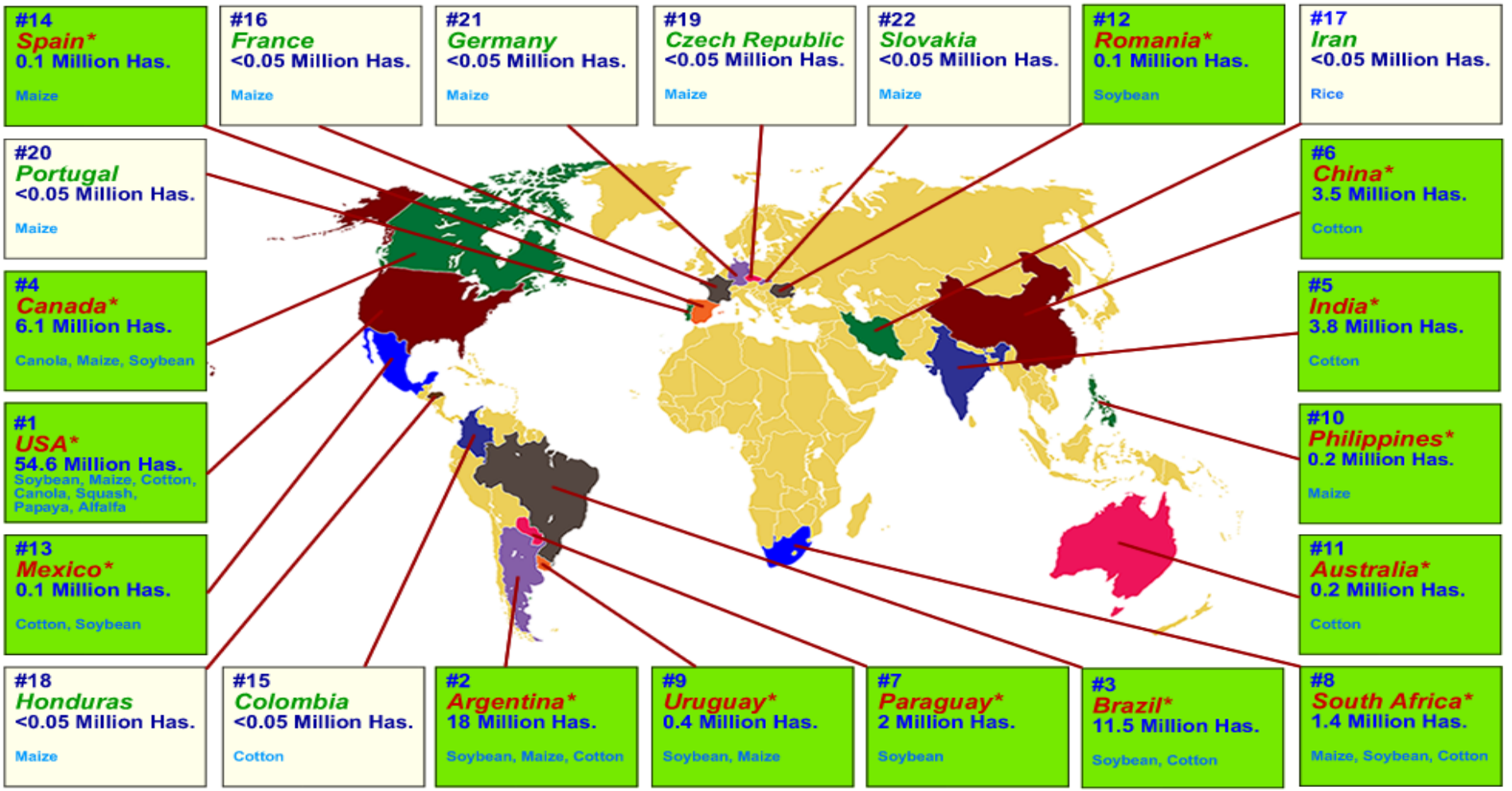
Remove Antinutrients/allergens/ Toxins

Agronomic Traits – $30B

Biotic/ Abiotic Stress /Yield

1st Wave **2nd Wave** **3rd Wave** **4th Wave**

Biotech Crop Countries and Mega-Countries (2006)



* 14 biotech mega-countries growing 50,000 hectares, or more, of biotech crops. (James, 2007)

- Biotech Crops 2006: 252 M acres (102 M hts)
- 22 countries (11 LDC) 13% increase over 2005
- 10.3 M farmers up from 8.5 M in 2005
- 90% resource-poor LDC farmers (9.3 M -7.7 M 2005) most Bt cotton

Benefits 1996- 2006

- Sustainable Agriculture Development Key To Poverty Alleviation, Food Security and Environmental Protection
- 10 year cumulative net benefits $27B, LDC $13 B
- Pesticide spraying down by 380 M lbs (172 M Kg.) Environmental footprint of pesticide use by 14%.
- GM reduction in 9.4 billion kg of CO_2 emissions in 2004 equivalent removing 5 M cars from the roads (Brookes 2005)
- Herbicide-Tolerance - increase in no- till: reduction in erosion, soils much healthier, organic matter, less soil compaction, fuel use down by 20 gals/acre
- Organisms in “Bt crops” fields fared better in trials than those with insecticides (Marvier et al 2007)
- CP papaya saved Hawaii papaya industry (and helped organic farmers!)

Benefits 1996- 2006

- India, the largest cotton growing country in the world, 3X increase Bt cotton area to 3.8 MHa
- China BT rice GM used pesticides less than once per season; conventional rice used pesticides 3.7 times/season (Rozell, 2005)
- Pesticides cost applied to the conventional rice was 8 to 10 times as high as GM. 80-percent reduction in pesticide use
- Significant decrease in adverse health effects –
- Lives saved !
- BT corn 90% reduction in mycotoxin fungi produced fumonisins - total US benefit was estimated at $23 million annually. (Wu, 2006)
- Blight-resistant potato -UI study concluded for major potato-producing regions of the world would be $4.3 billion. (University Idaho)

Developing countries & small holders benefit from biotech

China

India

S. Africa

1. ISAAA ; 2. Field trials; 3. Makhathini Flats

Bt cotton delivers economic advantages over conventional cotton[1]

	China	India[2]	South Africa[3]	Mexico
Farm Size	0.5Ha	2Ha	< 3Ha	20Ha
Increased Yield	5~10%	40%	25%	3~20%
Reduced Insecticide	50~77%	50%	32%	50%
Positive Economic Return	$360 - ~550/Ha	$75 - ~200/Ha	$50/Ha	$45 - ~600/Ha

Increased income and time savings

From Genomics to Improved Crops

The 2 Phases of Biology

Genotype ⇄ Phenotype

Reverse Genetics

Forward Genetics

Gene ⤷ RNA ⤷ Proteins ⤷ Metabolites ⤷ Organism

Bioinformatics

DNA Sequence Map

Transcriptome

Proteome

Metabolome

Profiling

Genomics Platform

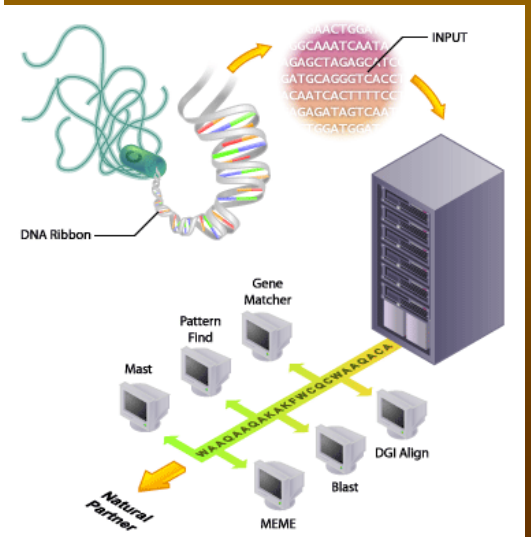
Phase 2

Molecular Breeding

New Plant Traits

Transgenics

Improved Crops



Phase 1

---omics – Metabolic Pathways - Systems Biology –Epigenetics –RNAi- Paramutation - - Adaptive technology - transgenomics

Improved Nutritional Content

- Many common food crops not perfect for nutritional requirements of humans or animals.

Functional Foods: offering potential health benefits that go beyond satisfying basic nutritional needs.

- Functional components associated with least four of leading causes of death: cancer, diabetes, cardiovascular disease, and hypertension (aging?)

Macro:

- •Protein (Better ratio, High lys/ meth, artificial)
- •Carbohydrates (>complex – resistant starch)
- •Fats (Higher Oleic (MUFA), Ω-3, Ω- 6 GLA, CLA, MCFA, lower SFA, PUFA)
- •Fibre (low for animals, high for humans (prebiotics, FOS, inulins, lignans)

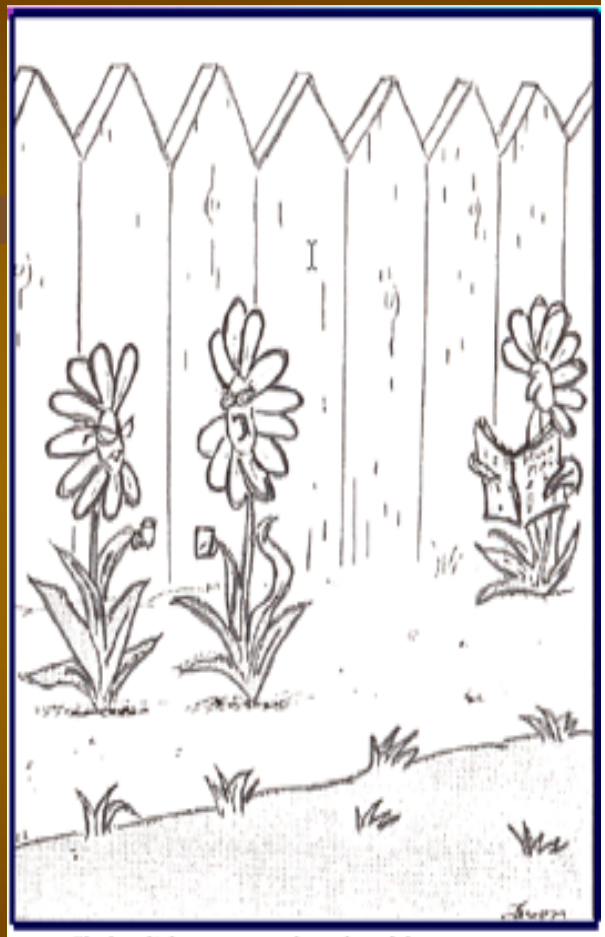
Micro: Vitamins (Golden rice II, vit C, vit E), co-factors, minerals (Fe, Ca, Zn)

Phytochemicals: carotenoids, flavonoids, isoflavones, isothiocyanates, phenolics (Sirtuins)

Anti-nutrients: TI, Phytate; Allergens: soy P34, Toxins: glycoalkaloids, cyanogenic glucosides

Concerns

- Antibiotic Resistance
  - Transposon tagging
  - Positive selection – exclusive energy source
- Gene Flow-
  - Space
  - Male sterility
  - "Terminator" technology
  - Chloroplast transformation
- Effect on non-target species
  - Tissue specific expression
  - Chloroplast transformation
- Loss of effectiveness – resistance management
  - Refugia
  - Gene Pyramiding
  - Gene shuffling
- Reduced diversity
  - More sources of genetic diversity – rescue heritage varieties and landraces
- Co-existence



"I don't have any hard evidence, Connie--but my intuition tells me that Ed's been cross-pollinating.

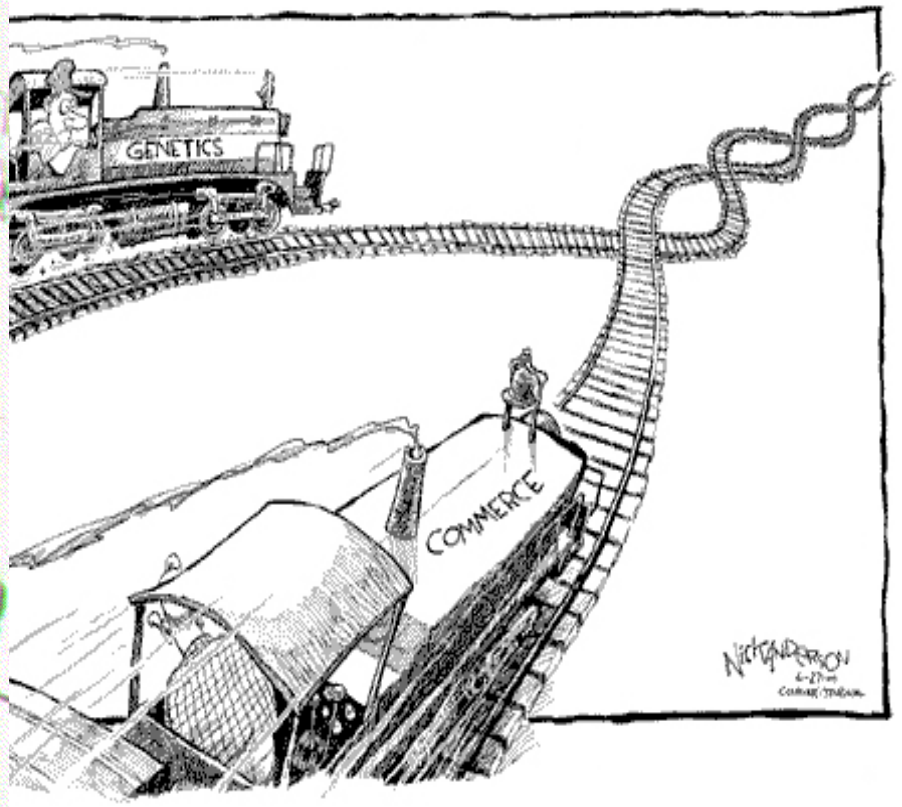
Following are from "trusted" Sources? EU? WHO?

- EU Commission Report – Results from 400 teams over 15 years- The use of more precise technology and the greater regulatory scrutiny probably make GMOs even safer than conventional plants, foods.
- WTO: Europe failed to follow its own procedures, resulting in undue delay of decisions (Feb 2006).
- Declaration signed by over 4,000 scientists including 25 Nobel Laureates

http://europa.eu.int/comm/research/fp5/eag-gmo.html

World Health Organization (2005)

- Indirect benefits include reduction in ag chemical usage, enhanced farm income, crop sustainability and food security, particularly in developing countries
- The report concludes, "GMOs offers potential of increased agricultural productivity, improved nutritional values that can contribute directly to enhancing human health and development..
- http://www.who.int/foodsafety/biotech/who_study/en/index.html



Greatest Challenges going forward

Technical
Intellectual Property: PIPRA - Specialty crops – FTO
Liability, co-existence
Biosafety: so–called – LDCs – Specialty crops
Acceptance: - countering fear and misinformation
- moral imperative: real need v. hypothetical risk

Take Home Message

Biotechnology is a useful tool not a panacea

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

Trust:

- Openness Competence
- Scientific honesty Admission of problems

Communication:

- Proactive agenda setting
- Providing easily understandable contextual information