Food & Agricultural Biotechnology

Health Impacts in Developing Nations
Program Objectives

1. Describe agricultural biotechnology applications currently utilized or being studied for use in developing nations.

2. Identify biotechnology’s role in food quality and availability, economic development, and the health of farm workers.

3. Describe guidance from international authorities regarding safety testing and regulation of agricultural biotechnology.

4. Compare and contrast examples of uses and regulation of agricultural biotechnology in specific developing nations and world regions.
Module Outline

I. Global Overview
   a. Definition
   b. Adoption
   c. Regulation and Safety

II. Understanding Agriculture, Food, and Health in Developing Nations

III. Developing Nations
   a. Adoption
   b. Benefits
   c. Research & Development
   d. Case Studies
   e. What will the Future Hold?

IV. Resources & References
Global Overview: Definition
Agricultural Biotechnology Defined:

- Various agricultural and food production techniques that aim to improve agricultural conditions and produce better food.

Modern Agricultural Biotechnology:

- Identification and transfer of specific gene(s) that create(s) a desired quality in a plant.
- More precise way to produce plants with certain beneficial characteristics—such as insect protection or better nutrition.

Photos courtesy of Wayne Parrot, PhD, University of Georgia
Global Biotechnology: Adoption

- 60-fold increase in acreage, 1996 to 2006
- In 2006:
  - 252 million acres (102 million hectares)
  - 22 countries
  - 10.3 million farmers

Traits expressed in crops:
- Bt (insect protected)
- HT (herbicide tolerant)
- VR (virus resistant)

%Global Crop Acreage:
- 64% soybean
- 38% cotton
- 18% canola
- 17% maize

Increase of 13%, 12 million hectares (30 million acres) between 2005 and 2006.
Source: Clive James, 2006.
Global Overview: Regulation and Safety
Deemed safe by scientific and regulatory authorities globally for food, animal feed, and environmental safety.
Global Biotechnology: An Example of Safety Assessment Cooperation

- Assessing Allergenicity of Genetically Modified Foods
  - 2000: Decision tree adopted
  - 2001: 28 experts reaffirmed and recommended integrating emerging research and modifying, as needed
  - Decision Tree is utilized worldwide
Global Biotechnology: Scientific Support

- American Medical Association (AMA)
- European Food Safety Authority (EFSA)
- Food and Agricultural Organization (FAO)
- Institute of Food Technologists (IFT)
- Royal Society of London, U.S. National Academy of Sciences, Brazilian Academy of Sciences, Chinese Academy of Sciences, Indian National Science Academy, Mexican Academy of Sciences, and Third World Academy of Sciences
- Society of Toxicology
- US Food and Drug Administration (FDA)
- US Department of Agriculture (USDA)
- US Environmental Protection Agency (EPA)
- World Health Organization (WHO)
Global Biotechnology: Challenges to Cooperation regarding Trade Regulation

Cartagena Protocol on Biosafety
• Designed to address biodiversity
• Biotech crops and seeds require approval and notification prior to importation
• Complexity and extended scope raise interpretation, implementation, and resource challenges
• 195 nations have ratified the Protocol
• Critics, including the US, have concerns that the Protocol is not science-based
Understanding Agriculture, Food, and Health in Developing Nations
Agriculture, Food, and Health in Developing Nations

• AGRICULTURE plays critical role:
  • Engine of ECONOMIC GROWTH
  • Employer to nearly ½ labor force

• Enhancing agricultural productivity to include better quality, quantity and consistency means:
  • BETTER DIETS
  • HIGHER INCOMES

1% increase in yield can increase income by 100% for 44% of Sub-Saharan Africans
Food & Agricultural Biotechnology: Impact of Improved Agricultural Productivity on Human Health

- Reduced pesticide use
- Transition to use of safer pesticides
- Improved water quality
- Improved air quality
- Improved soil quality
- Produce more consistent food supply
- Produce more food/nutritional value per crop
- Higher farm/family income
- Stimulation of local economies
Agriculture, Food, and Health in Developing Nations

- 854 million hungry people in world with 820 million (96%) of those individuals in developing countries
  - In Africa:
    - 1/3 undernourished
    - 1/4 of children underweight
    - 1/3 of children stunted
  - Population growth compounding problem!
  - 40% more food needed from agriculture to meet needs of projected population

“Hunger, poverty, and disease are interlinked, with each contributing to the presence and persistence of the other two.”

*World Health Organization, 1997*
Many BARRIERS to addressing hunger and malnutrition through increasing agricultural production

Failure to address agricultural production, however, would undermine self-sustainability

Fortunately biotechnology does not rely on economies of scale. The power of biotechnology is delivered via the seed itself.
Developing Nations: Adoption
Developing Nations: Adoption

2006
- 11 of 22 countries with biotech crop acreage were developing nations
- 40% global acreage in developing nations (vs. 14% in 1997)
- Of 10.3 million farmers who planted biotech crops in 2006:
  - 90% or 9.3 million were small, resource-poor farmers from developing countries
    - Increased income from biotech crops contributed to poverty alleviation.
    - Most reside and work in China, India, the Philippines, and South Africa.
Developing Nations: Benefits
Biotechnology is making and has the potential to make further essential contributions to resolving certain food and agricultural issues in the developing world.

- Human Health
- Environmental
- Economic

“Because trace minerals are important not only for human nutrition, but for plant nutrition as well, plant breeding holds great promise for making a significant, low-cost, and sustainable contribution to reducing micronutrient, particularly mineral deficiencies in humans, and may have important spinoff effects for increasing farm productivity in developing countries in a way that is environmentally-beneficial.”

(Bouis, Graham, and Welch, 1999)
Developing Nations: *Human Health* Benefits

- Improved nutrition
  - Golden rice
  - Golden mustard oil
  - Higher protein potato
  - Micronutrient-enhanced cassava, rice, etc.
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Developing Nations: *Human Health* Benefits

- Reduced toxin formation, in the field and post-harvest
  - Reduced mycotoxin formation in insect-protected (Bt) varieties
  - Varieties developed to produce less naturally-occurring toxin
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Developing Nations: *Human Health* Benefits

- Increased food production
  - Disease and pest resistance
  - Resulting yield increases
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Developing Nations: *Human Health* Benefits

- Farmer health
  - Reduced pesticide exposure during spraying
  - Economic gains translate into better diets and health care
Developing Nations: *Environmental* Benefits

- Global Reductions in Pesticide Use
  - ↓ 224 million kg (6%) active ingredient, 1996-2005
  - Environmental Impact Quotient (EIQ)
    - ↓ 15.3%, 1996-2005

**Human health impact?**
Reduce farmer exposure.
Improve air and ground water quality.
Improve diets through increased net income to farmer.
Developing Nations: *Environmental* Benefits (continued)

- **Reductions in Greenhouse Gas (GHG) Emissions**
  - Less fossil fuel used to spray pesticides and/or till the soil
    - $\rightarrow$ ↓ 962 million kg CO$_2$
    - $\rightarrow$ Equivalent to 427,556 average family cars
  - More organic carbon sequestered in soil with no-till and reduced-till systems
    - $\rightarrow$ ↓ 8,053 million kg CO$_2$
    - $\rightarrow$ Equivalent to 3,579,298 average family cars

**Human health impact?**

Improve air quality.
Improve diets through increased net income to farmer.
Developing Nations: *Economic* Benefits

- 2005 direct *global* farm income benefit*: $5 billion
- 2005 direct *developing nations* farm income benefit*: $2.75 billion

**Human health impact?**
Allow farming families to eat better. Channel resources into local economy, allowing non-farming families to eat better.

* Farm income benefit accounts for impact on yield, key costs of production (seed, crop protection, fuel, labor), crop quality, facility of planting 2nd crop within a season, price changes
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Developing Nations: R&D
Developing Nations: Research and Development

Research goals relevant to developing nations:
- Reduce need for agrochemicals
- Pest and disease resistance
- Increased tolerance to drought and saline soils
- Prolonged shelf life and other enhanced product characteristics
- Improved nutritional value

R&D is active worldwide
- in specific countries, and
- through international collaborative research groups

The reality is that poor countries have vibrant programs of public biotech research.

Joel Cohen, International Food Policy Research Institute, 2004
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Developing Nations: Case Studies
Case Study: South Africa

• HEALTH AND AGRONOMIC NEEDS
  – 11% population employed in agriculture
  – Ag is 4% of GDP
  – Severe HIV/AIDS crisis, affecting ability to work and economic status of families
  – Common crops: cotton, maize, potato, soybean, sugarcane, wheat

• ADOPTION
  – 1999: One of first developing countries to commercially approve biotech crops
  – 2005 to 2006: 180% increase (3.5 million acres in 2006)
  – 8th largest acreage worldwide
  – Planted by several thousand farmers, including many female Bt cotton farmers
  – Crops:
    • Bt and HT white maize for food
    • Bt and HT yellow maize for animal feed
    • HT soybean
    • Bt, HT, and stacked (Bt + HT) cotton
Case Study: South Africa

- **ECONOMIC**
  - Farm income ↑$76 million, 1998-2005
  - Makhatini Flats cotton farmer survey (‘98-’01)
    - Gross margin increase: $86-93/ha
    - Revenue, yield, harvest labor, seed cost ↑
    - Pesticide cost, pesticide spray labor ↓
  - Social implications for female farmers supporting families

- **ENVIRONMENTAL**
  - EIQ ↓ ranged from 7% for HT soybean to 0.44% for HT maize

“Walking with a knapsack sprayer on his back, a farmer has to cover a distance of 10-20 km to apply pesticide to one hectare of cotton. Water has to be carried by hand from communal water sources, and in dry areas clean water is a very scarce commodity. Illness due to exposure to pesticides is not uncommon among small-scale farmers.”

*Gouse, Pray, Schimmelpfennig 2004*
Case Study: South Africa

- R&D
  - University of Cape Town
    - Maize resistant to virus, drought
    - Tobacco to produce vaccines against HIV and HPV
  - South African Sugar Experiment Station
    - HT sugar cane (see photo at left: control in middle, HT crop on either side; courtesy of AgBioForum)
  - India-Brazil-South Africa Trilateral Commission, biotech research collaboration
Case Study: India

- **HEALTH AND AGRONOMIC NEEDS:**
  - Green Revolution history
  - Still, home to most hungry in world—300 million food insecure
  - 60% employed in agriculture
    - Ag represents 22% of the GDP
    - Feeds into cotton industry (4% GDP)

- **ADOPTION:**
  - 9.4 million biotech crop acres: 3-fold or 192% increase, 2005 to 2006
  - 5th largest biotech cultivator worldwide
  - 2.3 million farmers
Case Study: India

• **ECONOMIC:**
  – 2002 to 2005, farmer income increased US$463 million due to biotech
  – Yield of Bt vs. conventional cotton was 45% higher in 2002 and 63% higher in 2003

• **ENVIRONMENT**
  – 78% less pesticide sprayed in 2002 on Bt vs. non-Bt cotton; 83% less in 2003
  – EIQ ↓3%, 1996-2005
Case Study: India

- R&D
  - Dept of Biotech, Ministry of Science and Technology: 6 centers of plant molecular biology in 1990
  - IBSA Trilateral Commission
  - Crops under study in India: chickpea, banana, blackgram, brassica, cabbage, cauliflower, coffee, cotton, eggplant, maize, muskmelon, mustard/rapeseed, pigeonpea, potato, rice, tobacco, tomato, and wheat.
  - Agricultural Biotechnology Support Program II (ABSPII):
    - Fruit and Shoot Borer Resistant Eggplant *(photo at left courtesy of ABSPII)*
    - Drought Tolerant Rice
    - Salinity Tolerant Rice
    - Late Blight Resistant Potato
    - Tobacco Streak Virus Resistant Groundnut and Sunflower
Case Study: The Philippines

- **HEALTH AND AGRONOMIC NEEDS:**
  - 36% population employed in ag sector
  - Ag is 14.8% GDP
  - Major crops: banana, cassava, coconut, corn, mango, pineapple, rice, sugarcane

- **ADOPTION:**
  - 100% increase, 2005 to 2006, to 0.2 million hectares
  - 10th largest biotech cultivator worldwide
  - 100,000 farmers
  - Crops:
    - Bt, HT, and stacked maize for animal feed
Case Study: The Philippines

- **ECONOMIC**
  - $8 million farm income ↑, 2003-2005
  - Yield ↑25%

- **ENVIRONMENT**
  - Potential for reduced pesticide usage

- **HEALTH**
  - Potential for reduced mycotoxin formation
  - Potential for reduced pesticide exposure
Case Study: The Philippines

• R&D
  – Agricultural Biotechnology Support Program II (ABSPII):
    ▪ Fruit and Shoot Borer Resistant Eggplant
    ▪ Drought Tolerant Rice
    ▪ Salinity Tolerant Rice
    ▪ Late Blight Resistant Potato
    ▪ Tobacco Streak Virus Resistant Groundnut and Sunflower
  – Philippine Rice Research Institute
    ▪ Golden Rice
    ▪ Virus and Blight Resistant Rice
  – Institute of Plant Breeding of the University of the Philippines at Los Baños
    ▪ VR papaya (photo at left: virus-resistant on right, control on left; courtesy of AgBioForum, Gonsalves 2004)
Developing Nations: What will the future hold?
Critical Factors for Continued Benefits in Developing Nations

- Science-based regulatory and trade policies
- Infrastructure and access issues
- Responsible farm management and environmental stewardship
- Public-private partnerships
- Consumer acceptance
"Biotechnology is not the enemy…hunger is"

Jimmy Carter
Former President of the U.S. and current activist against global hunger

"GM technology, coupled with important developments in other areas, should be used to increase the production of main food staples, improve the efficiency of production, reduce the environmental impact of agriculture, and provide access to food for small-scale farmers."

National Academy of Sciences
To Learn More:

Agricultural Biotechnology Support Project II
http://www.absp2.cornell.edu/

AgBio World
www.agbioworld.org

Biotechnology Industry Organization
www.bio.org

Consultative Group on International Agricultural Research
www.cgiar.org/

Council for Biotechnology Information
www.whybiotech.org

Institute of Food Technologists
www.ift.org
To Learn More…continued

Institute of Medicine, National Academies of Science  
www.iom.edu/report.asp?id=21496

International Food Information Council Foundation  
www.ific.org/food/biotechnology

International Food Policy Research Institute  
www.ifpri.org

International Service for the Acquisition of Agri-biotech Applications  
www.isaaa.org

Society of Toxicology  
www.toxicology.org/information/governmentmedia/gm)_food.html

US Regulatory Agencies Unified Biotechnology Web Site  
http://usbiotechreg.nbii.gov/
References


References

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References


• SEARCA Biotechnology Information Center and Philippine Department of Agriculture


References


