U.S. Embassy to the Holy See
Feeding a Hungry World:
The Moral Imperative of Biotechnology

in cooperation with the Pontifical Academy of Sciences
September 24, 2004

The Pontifical Gregorian University

According to the United Nations, one person dies from hunger and malnutrition every six seconds – nearly 15,000 every day. As many as 1.5 billion worldwide, mostly in developing countries, suffer from hunger and malnutrition. The magnitude of these avoidable deaths should challenge everyone to take steps to alleviate this crisis. At the beginning of the 21st century mankind has the ability to create crops that resist extreme weather, diseases and pests, use less water, require fewer chemicals, and are more nutritious than conventional crops. Scientists the world over have attested that genetically modified biotech foods could be a crucial element in the fight against hunger in the developing world. The world's needs and the potential of this new technology give rise to a moral imperative to investigate ways in which genetically modified foods can help the poor.

Among many who have spoken out on the subject is the Pontifical Academy of Sciences, which has argued that intellectual property rights "should not inhibit wide access to beneficial applications of scientific knowledge." The Academy has also called for closer study of ways to facilitate cooperation between the public and private sectors in the development of this modern genetic technology that can help promote solidarity and justice between the industrialized and developing worlds.

This conference will bring together prominent scientists, leading experts in humanitarian relief and agricultural development in the developing world, and farmers working with biotech foods to explore the potential of genetically-modified organisms to address hunger and malnutrition. We hope to share the experience of the experts with concerned individuals like you. Please join us in examining how biotechnology can contribute to protecting human life and promoting human dignity.

Table of Contents

Conference Agenda:

Welcome:
Rev. Michael Hilbert, S.J.
Dean of Canon Law, Pontifical Gregorian University

Introduction: H.E. Ambassador Jim Nicholson
U.S. Embassy to the Holy See

Session I:
Hunger in the Developing World

Moderator: Ambassador Nicholson

Speaker:
Dr. C.S. Prakash
Professor of Plant Molecular Genetics and Director of the Center for Plant Biotechnology Research at Tuskegee University, Alabama, U.S.A.

Session II:
The Theological and Moral Case for the Use of Biotech Food in the Developing World

Moderator:
Msgr. Frank J. Dewane
Undersecretary, Pontifical Council for Justice and Peace

Speaker:
Rev. Gonzalo Miranda, L.C., "GMO: Threat or Hope?"
Dean of the School of Bioethics, Pontifical Athenaeum Regina Apostolorum

Session III:
Scientific Advances in Biotech Crops: New Promise for the Hungry

Moderator:
H.E. Bishop Marcelo Sánchez Sorondo
Chancellor, Pontifical Academy of Sciences

Speakers:
Dr. Peter Raven, "GMOs and Science: What We Have Learned"
Director, Missouri Botanical Gardens
Engelmann Professor of Botany, Washington University in St. Louis, Missouri, U.S.A.

Dr. C.S. Prakash, "Global Hunger, Can Biotechnology Help?"
Professor of Plant Molecular Genetics and Director of the Center for Plant Biotechnology Research at Tuskegee University, Alabama, U.S.A.

Session IV:
How Developing-World Farmers Have Used Biotech Crops

Moderator:
H.E. Ambassador Javier Moctezuma Barragán
Embassy of Mexico to the Holy See

Speakers:
Dr. Carl Pray
Professor and Director of the Graduate Program, Department of Agricultural Food and Resource Economics, Rutgers University, New Jersey, U.S.A.

Mr. Edwin Y. Paraluman
Farmer; Chairman, SARGEN Integrated Irrigators Federation, General Santos City, Philippines

Ms. Sabina Khoza, "The Impact of Bt Maize: A Farmer's Perspective"
Small-scale farmer, General Secretary of the National African Farmers' Union, Gauteng, South Africa

Screening of "Harvest of Fear," a PBS Frontline/NOVA in-depth television documentary on biotechnology

Session V:
The Regulation of Biotech Foods

Moderator:
Ambassador Nicholson

Speaker:
Dr. Lester M. Crawford
Acting Commissioner, Food and Drug Administration, United States Department of Health and Human Services

Session VI:
Debunking the Myths on Biotech Food and the Developing World

Moderator:
H.E. Bishop Marcelo Sánchez Sorondo
Chancellor, Pontifical Academy of Sciences

Introductory Speaker:
Dr. Piero Morandini
Researcher in Plant Physiology, Department of Biology, University of Milan

Panel Discussion followed by Q&A with:
Mr. Paraluman, Ms. Khoza, and Drs. Crawford, Raven, Prakash, Pray, and Morandini

Lecturers

Dr. Lester M. Crawford, *Acting Commissioner, Food and Drug Administration, U.S. Department of Health and Human Services, Washington, D.C., U.S.A.*

As Acting Commissioner of the FDA, the principal U.S. consumer protection agency, Dr. Crawford ensures the safety and protection of public health. Previously, he was Chair of the Department of Physiology-Pharmacology at the University of Georgia, Administrator of the Food Safety and Inspection Service (USDA) and Deputy Commissioner of FDA. From 1997-2002, Dr. Crawford was Director of the Center for Food and Nutrition Policy at Georgetown University and at Virginia Tech. He has played major roles in mandatory nutrition labeling, the formation of the WTO, and the control of chemical and microbiological contaminants of food. He has been an advisor to the World Health Organization for much of his career. Dr. Crawford is a Member of the National Academy of Sciences Institute of Medicine, a member of the French Academy of Veterinary Medicine, a Fellow of the Royal Society of Medicine (UK), and a Fellow of the International Society of Food Science and Technology. He is a recipient of the Wooldridge Award, the British Veterinary Association's highest award. Dr. Crawford received his Doctor of Veterinary Medicine (DVM) from Auburn University, his PhD in pharmacology from the University of Georgia, and his Honorary Doctorate (MDV) from Budapest University.

Ms. Sabina Khoza, *small-scale farmer and General Secretary of the National African Farmers' Union, Gauteng, South Africa.*

Sabina Khoza, a poultry farmer, is leading the way in environmentally safe food production methods in South Africa. Using her experience with permaculture, she educates her community on eco-friendly agricultural practices through the Fair Deal Education and Production Training Centre, which she created at her poultry farm. Among her many positions of leadership within the sphere of farming, Ms. Khoza is the president of the Gauteng Provincial Farmers' Union, the secretary-general of the National African Farmers' Union, the chairperson of the Zuurbekom Farmers' Association, and a representative for South African rural women on the International Federation of Farmer Producers. She has received numerous farming-related awards, including Female Farmer of the Year. Additionally, she is a recipient of South Africa's 2004 Women of the Year Award, which recognized her work in educating farmers at her training center.

Rev. Gonzalo Miranda, L.C., *Dean of the School of Bioethics, Pontifical Athenaeum Regina Apostolorum, Rome.*

Father Miranda is a native of Gerona, Spain. He obtained a diploma in Humanistic Sciences from Center of Humanistic Studies, adminstered by the Legionaries of Christ in Salamanca (1975), and later master's degrees in Philosophy and in Sacred Theology from the Pontifical Gregorian University in Rome. Father Miranda completed a doctorate in Moral Theology at the Pontifical Athenaeum Regina Apostolorum with a thesis on "Euthanasia and the Encyclical 'Evangelium Vitae.'" He is currently Dean of the School of Bioética at the Pontifical Athenaeum Regina Apostolorum and a member of the Board of Directors of the Center of Bioethics of the Catholic University of the Sacred Heart, Rome. Father Miranda also serves as Director of the Master in Bioethics program at Regina Apostolorum, and is a member of the society Medicina e Morale in Rome. He is

also a member of the Scientific Committee of Medicina y Etica (Mexico), the Scientific Committee of the magazine Vida y Etica (Argentina), the International Committee of Bioethics, the World Federation of Catholic Universities, and the Board of Directors of the Movimento per la Vita Italiano. Father Miranda has published extensively on medical, moral and bioethical issues, including drug dependency, HIV/AIDS, abortion, euthanasia, human sexuality, contraception, the mass media, family life, and stem cell research. His participation in international conferences has also been extensive.

Dr. Piero Morandini, *Researcher in Plant Physiology, Department of Biology, University of Milan.*

After receiving a degree in Chemistry at the University of Turin in 1986, Dr. Morandini focused his interests on the field of biology. He then worked for three years in Munich at the Max Planck institute for Biochemistry and the Zoological institute of the Ludwig-Maximilian University, specializing in the field of molecular biology and development of Dictyostelium. He moved on to Cambridge (UK), working on the same subject at the Medical Research Council in the Laboratory of Molecular Biology for three years. From 1994 he worked at the University of Milan's Department of Biology in the Plant Physiology and Biochemistry section, working on fundamental problems of plant biology and biotechnology. Since 1999 he has been a researcher in plant physiology, teaching Genetic Biotechnology to agricultural biotechnology students at the University of Milan. He also teaches in the master's program in Environmental Sciences of the Pontifical Atheneum Regina Apostolorum. Dr. Morandini is the author of several scientific publications in the field of molecular biology and biotechnology and collaborates with several newspapers, including *Avvenire* and *Tempi*, to improve the public understanding of agricultural biotechnology. He is a member of the Scientific Committee for Agricultural Biotechnology of the Lombardy Region.

Mr. Edwin Y. Paraluman, *Farmer and Chairman of SARGEN Integrated Irrigators Federation, General Santos City, Philippines.*

Edwin Paraluman began promoting the use of modern farming methods in his country after having had particular success with growing pesticide-resistant Bt corn. Among his leadership roles in the agricultural community, Mr. Paraluman is president of the Nursery Farmers' Irrigators Association for General Santos City, secretariat coordinator for the Asian Farmers' Regional Network, director for social marketing for the Biotech Coalition of the Philippines, and chairman of both the Farmers' Federation of the Southern Philippines and the Provincial Farmers' Action Council in South Cotabato. With numerous positions of leadership in the farming community, he has advocated and networked to ensure responsible farming in and to accelerate the transfer of modern technology to the Philippines.

Dr. C.S. Prakash, *Professor, Plant Molecular Genetics, Director, Center for Plant Biotechnology Research, Tuskegee University, Alabama, U.S.A.*

Founder and President of AgBio World Foundation, Dr. Prakash oversees the research on food crops of importance to developing countries as well as the training of scientists and students in plant biotechnology at Tuskegee University. He is actively involved in enhancing societal awareness of food biotechnology issues around the world and has worked to promote biotechnology research and policy in developing countries

in Asia and Africa by training students and scholars and by conducting collaborative research and lectures. His Internet website, www.agbioworld.org, has become an important portal, disseminating information and promoting discussion on this subject among scientists, policy makers, activists, and journalists. His outreach activities also include writing commentaries, delivering public lectures, providing media interviews, and moderating the Internet discussion group/newsletter, AgBioView. He recently served on the USDA's Agricultural Biotechnology Advisory Committee and continues to serve on the Advisory Committee for the Department of Biotechnology for the government of India. Dr. Prakash has been recognized by the magazine, Progressive Farmer, which awarded him the "Man of the Year" award "in service to Alabama Agriculture" and by the Council for Biotechnology Information, which acknowledged him as a "pioneer, visionary, and innovator behind the progress and promise of plant biotechnology."

Dr. Carl Pray, *Professor and Director of the Graduate Program, Department of Agricultural Food and Resource Economics, Rutgers University, New Jersey, U.S.A.*

Since receiving his Ph.D. in 1978 in Economic History from the University of Pennsylvania, where he focused on the development of the agricultural research, extension, and education system of Northern India and Pakistan, Dr. Pray has been an influential contributor in the in the field of agricultural development. After receiving his Ph.D., he worked as a research associate in agricultural development with the Bangladesh Agricultural Research Council and with the Asian Agricultural Research Project at the University of Minnesota before joining Rutgers in 1986. Dr. Pray has participated in research and outreach activities focused on improving the efficiency of investments in agricultural research in Asia, and his work provided the justification for USAID, World Bank, and Asian governments to increase their investments in this area of development. His contributions also include documenting the impact of biotechnology on small farmers in developing countries and understanding the policies that are influencing the adoption of biotechnology. He has advised the Russian government on seed policy for the World Bank and the Chinese government on privatizing its seed industry. Among many awards and honors, the Association for International Agriculture and Rural Development selected Dr. Pray as the recipient of its 2004 Special Service Award, the China Ministry of Agriculture honored him with the Award for Outstanding Scientific Progress on Agricultural R&D Policy Study, and the Rockefeller Foundation awarded him with the leadership position of a Team Residency at the Bellagio Study and Conference Center on Chinese agricultural research. He is also the recipient of grants from the Rockefeller Foundation, U.S. Department of Agriculture, and International Food Policy Research Institute. Dr. Pray, a well-known author on Agricultural Science Policy and Economic Development, contributed background papers to the recent FAO State of Food and Agriculture 2003-4: Agricultural Biotechnology: Meeting the Needs of the Poor.

Dr. Peter Raven, *Member of the Pontifical Academy of Sciences, Director of the Missouri Botanical Garden and Engelmann Professor of Botany at Washington University in St. Louis, U.S.A.*

Since receiving his Ph.D. from the University of California, Los Angeles and subsequently serving as an associate professor in the Department of Biological sciences at Stanford University, Peter H. Raven has made strong contributions to the field of

biogeography. He champions research around the world to preserve endangered plants and is a leading advocate for using biodiversity and for conservation and sustainable development. Dr. Raven has become increasingly involved with the role of GM crops in improving the productivity of agriculture, and thus, contributing to the conservation of plants and animals in the non-cultivated, neighboring lands. He is currently Chairman of the National Geographic Society's Committee for Research and Exploration; Chair of the Division of Earth and Life Studies of the National Research Council; and Vice President of Sigma Xi and of the American Association for the Advancement of Science. In recognition of his work in science and conservation, Dr. Raven is the recipient of numerous prizes and awards, including the National Medal of Science, the highest award for scientific accomplishment in the U.S.; the prestigious International Prize for Biology from the government of Japan; the Environmental Prize of the Institute de la Vie; the Sasakawa Environment Prize; and Guggenheim and MacArthur Foundation Fellowships. He is a member of the U.S. National Academy of Sciences, the American Philosophical Society, the Third World Academy of Sciences, and the Pontifical Academy of Sciences, and he is also a Fellow of several academies in Asia, Australia, Europe, and South America. Dr. Raven holds honorary degrees from universities in the United States, Russia, Sweden, and Argentina. He has written numerous books and publications, both popular and scientific, including Biology of Plants (co-authored), the internationally best-selling textbook in botany.

U.S. Embassy to the Holy See 20th Anniversary Conference Feeding a Hungry World: The Moral Imperative of Biotechnology

in cooperation with the Pontifical Academy of Sciences

Opening remarks as prepared for delivery by Ambassador Jim Nicholson

September 24, 2004

Welcome and thank you for joining the U.S. Embassy and the Pontifical Academy of Sciences today to explore a subject of critical importance to the millions of people in our world who suffer from hunger and malnutrition. Every minute, eleven children below the age of five years die from hunger. Every day, thirteen thousand people die from hunger. Every year, over a billion and a half suffer from hunger and malnutrition. The suffering of so many in today's world of plenty is an affront to human dignity. It presents a moral challenge to people of goodwill everywhere to explore every avenue to meet this most basic need of our fellow man. In short, a hungry world needs to be fed, and biotechnology offers tremendous potential to meet this obligation to our fellow man.

Meeting this obligation is essential because hunger and malnutrition are an affront to human dignity, and the advancement of human dignity is the most basic goal of a civilized world. It is also the foremost objective of American foreign policy, because we recognize that when we commit ourselves to combating hunger and malnutrition, we can make our world more peaceful, more secure. We know that feeding a hungry world today means nourishing the cause of liberty and freedom for tomorrow. Peace, as Pope John Paul II never tires of telling the world, must be built on foundations of truth, justice, liberty and love. And all of these forces compel us to help others meet their most basic needs – and none is more basic than food.

Saint James taught the early Christians that if a brother or sister lacks their daily nourishment, and one of you says to them, 'Go in peace, be warmed, and be filled' without giving them what is necessary for the body, what good does it do? Today, we are called to heed these words and answer that call by sharing with others the nourishment they need to live with dignity.

The United States has been answering that call for over half a century. Fifty years ago, U.S. President Dwight Eisenhower launched the Food for Peace program which has provided more than 106 million metric tons of American food at a cost of about $33 billion to more than 150 countries. At the time, he pointed out that "the peace we seek can be fortified not by weapons of war, but by wheat and cotton, by milk and wool, by meat and timber and rice." This response to the world's needs he launched continues today. The United States is the largest contributor to the World Food Program's hu-

manitarian relief efforts providing over half, and sometimes as much as two-thirds, of all food support every year.

Sadly, however, the international community's ability to respond to Saint James' call to assist those in need was imperiled two years ago when anti-biotech activists sowed fear among African governments and convinced them to reject World Food Program assistance provided by the United States. The government of Zambia even ordered food that had been delivered to be packed up and shipped out of the country – this while hundreds of thousands of Zambians were at risk of starvation. In the midst of this spectacle, some Catholic activists even suggested that it would be better for thousands to die than to risk eating the same corn that Americans have been eating in billions of servings over nine years. This seemed to me quite a long way from Saint James' instruction, and it brought home to me the importance of working with the Holy See to promote a clear, science-based understanding of biotechnology so that people in developing countries who can benefit from its promise are able to do so.

Thankfully, this effort has been greatly facilitated by the commitment of our co-host, Bishop Marcelo Sanchez Sorondo of the Pontifical Academy of Sciences. From the outset, the Academy has taken a careful, balanced, and open approach to biotechnology, closely studying the risks and the potential of the new technology, and concluding that "genetically modified food plants can play an important role in improving nutrition and agricultural products, especially in the developing world." The cause has also benefited greatly from the interest and openness of the Pontifical Council for Justice and Peace and the Pontifical Council for Health. A conference organized by Cardinal Martino of the Council for Justice and Peace last November did much to build understanding of this subject. Cardinal Martino told that gathering that man was called by God to be cultivator and custodian of creation, and was given the capacity to discover the causes, the laws, and the mechanisms governing creation. Cultivating, His Eminence observed, meant "to intervene, to decide, to make, and not to allow plants to grow randomly. Cultivate means to enhance and perfect, so that we have better and more abundant fruit." Continuing the Holy See's focus on feeding the hungry, Secretary of State Cardinal Angelo Sodano participated this week in a United Nations Summit to study the effectiveness of strategies to combat hunger and poverty. In his address to the Summit, Cardinal Sodano similarly urged government leaders to ensure that appropriate technologies to alleviate hunger be shared with the developing world.

At the end of the November Justice and Peace conference, Cardinal Martino pointed out that we have to continue efforts to understand the potentials of biotechnology, and encouraged all to do so. We are here today to continue this important work of understanding, of seeking the truth. In fact, we will have the opportunity to hear from some of the most preeminent scientists in the world working on biotechnology and ask them about their research. We will be able to hear from farmers from Africa and Asia who will share their experiences in using biotechnology and describe the opportunities and benefits it has brought with it. We will hear theological and ethical perspectives concerning how biotechnology should be applied to help meet the moral obligation to feed the hungry and to use our scientific skills, discoveries and talents for the betterment of human kind. And we will hear from the Director of America's Food and Drug Administration regarding the rigorous testing to which biotech foods are subjected in the United States, and how the benefits of this testing can be shared with governments in the developing world. Finally, at the end of the day, we will have a chance for an open discussion with

all of our presenters that will help us arrive at a better understanding of biotechnology and how it can help the developing world.

It is my hope that our program today will help inform this debate with sound science, genuine experience, and respect for human dignity. As Cardinal Martino pointed out, God has blessed mankind with great capacity to shape a better world. Through our God-given talents, farmers and scientists throughout world history have improved plants to be heartier, to produce more, and to provide more nutrition. In fact, most foods we eat today did not exist naturally in their current form. Today's scientists are continuing this tradition and have developed another tool to fight hunger and malnutrition that has proven to be safe and effective. With this tool, we have the ability to create crops that resist extreme weather, diseases and pests, and therefore use less water, require fewer pesticides, and can be more nutritious than conventional crops. This strikes me as something that is contributing to the common good. That is why scientists the world over – including in the developing world – have attested that genetically modified foods can be a crucial element in the fight against hunger.

In the face of this potential, some environmentalists, consumer groups and members of churches have challenged the overwhelming scientific evidence on the benefits of biotechnology and have succeeded in sowing fear among some governments in the developing world. Now I don't object to people having the ability to chose not to eat a genetically modified food, just as some people chose to eat only organic foods. But I believe that farmers and consumers in the developing world should also have the opportunity to become more productive, to raise their standard of living, and to use all the tools available to the developed world as they work to feed themselves and people in their own countries. The worst form of cultural imperialism is to deny others opportunities we have to take advantage of new technologies to raise up our human condition. Farmers should be able to decide for themselves whether a new seed generates more crops and income, reduces the cost of their pesticide, and allows them to become more self-sufficient. To do this, they need to be presented with truth, with facts, and I hope today's discussions will help disseminate the information needed to make intelligent choices.

In this effort to build understanding, I believe the Holy See's moral voice on food safety and on the potential of new technologies to help end world hunger and malnutrition can play a vital role in underdeveloped regions. Misinformation and fear can be just as deadly as drought and pests. Lives are put at risk just as much by diminishing people's capacity to feed themselves as they are by war and disease.

To meet the challenge of hunger today, the United States and the Holy See understand that the fight against hunger and malnutrition requires long-term strategies. Sending planeloads of food aid into crisis areas may feed the hungry today, but it does not resolve the deeper issues of permanent food security for the future. Biotechnology is part of the permanent answer. It is *not* a panacea. Poverty, wars, droughts, disease and other factors that contribute to hunger must also be addressed. But biotechnology does offer a real opportunity to foster the development of all countries, particularly the neediest. John Paul II has stated that technology, correctly applied, offers "a precious instrument" useful to resolve problems of hunger and disease. Keeping this instrument from the world's neediest, I believe, would be a grave injustice.

Thank you again for joining us today. I look forward to an elevating and enlightening discussion.

Our first speaker is well known to anyone who follows the biotechnology debate. **Dr. C.S. Prakash** is Professor in Plant Molecular Genetics and Director of the Center for Plant Biotechnology Research at Tuskegee University in Alabama. He has also been actively involved in enhancing the awareness of food biotechnology issues around the world. Dr. Prakash has actively worked to promote biotechnology research and policy in developing countries in Asia and Africa by training students and scholars, and through research collaboration and lectures.

Dr. Prakash has a bachelor's degree in agriculture and a master's in genetics from India, and obtained his Ph.D. in forestry/genetics from the Australian National University, Canberra. His research interests include studies on transgenic plants, gene expression, tissue culture and plant genomics. Dr. Prakash's group at Tuskegee University has led the development of transgenic sweet potato plants with enhanced protein level making them more nutritious. This morning, he will help us understand more about food security issues in the developing world because that's essentially where the potential of biotechnology can and *will* have its greatest impact.

Global Hunger: Can Biotechnology Help?

C.S. Prakash

Center for Plant Biotechnology Research
Tuskegee University, Alabama

Green Revolution

The Green Revolution is a process of technological development of agricultural techniques that began in Mexico in 1944 and has since spread throughout the world. The goal of the Green Revolution was to increase the efficiency of agricultural processes so that the productivity of the crops was increased, and to help developing countries face their growing populations' needs.

Benefits of the Green Revolution are:

- It lifted one billion plus out of poverty.
- The percent of undernourished declined from 38% to 19% in the past twenty years.
- Food consumption per capita has increased everywhere except in Africa – 18% Globally and 28% in Less-Developed Countries (LDCs).
- In India, food production increased from 50 to 205 million tons in the past five decades. Wheat alone increased from 6 to 82 million tons per year!
- Less starvation and famine.
- Increased food self-sufficiency.

However, there are criticisms of the Green Revolution. Some caveats are:

- It contributes to a loss in biodiversity. There is a focus on only a few grain crops, such as wheat, rice, and corn.
- There are high inputs of fertilizer and pesticide, which continue to be a significant source of pollution.
- It focuses on high resource farmers, using methods of heavy irrigation.
- It makes crop yield the major goal.
- It had little impact in Sub-Saharan Africa.

Stark Realities

Eight hundred million 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. Six hundred fifty million of the poorest live in rural areas. How do we combat these harsh realities?

Challenges Ahead

Some of the challenges facing LDCs with regard to food in particular are:

- Half of Sub-Saharan Africans are undernourished, and this number will increase to 70% by 2010.

- Food imports traditionally do not help the poor.
- Domestic food production provides for 97% of consumption in the low-income group.

We Must Produce More Food with Less Land, Less Water, and Fewer Chemicals!

Increasing Agricultural Productivity is the Key to Food Security in the Developing World:

Agriculture is the "Life Blood" of most countries, typically composing one-third of GDP. Seventy percent of people in the world are in farming; thus, agriculture contributes to a major share of all exports.

Why Do Developing Countries Have Problems with Food?

Some of the reasons that developing countries have problems with food are:

- Limited resources
- Poor governance
- Low agricultural productivity
- Poverty; poor distribution of food
- Protectionist policies
- Misguided priorities
- Low agenda of agriculture, natural resources, and community development ("Agriculture Resources and Development")
- Growing population
- Low purchasing power
- Civil strife and war

Problems with Agriculture in Developing Countries

There is a Green Revolution fatigue in many countries. The following may contribute to low productivity:

- Small holdings
- Subsistence farming
- Monsoons
- Limited water and land
- Disease, pests, drought, heat, weeds
- Storage and transportation

Modern Genetic Modification (GM)

Modern genetic modification is defined as inserting one or few genes to achieve desired traits. The transfer of genes into crop plants has been relatively precise and predictable. The changes are subtle and expeditious, and allow for flexibility.

Dominant GM Crops

A list of the most common GM crops:

- Herbicide Tolerant Soybean 41.4
- Bt Maize 9.1
- Herbicide Tolerant Canola 3.6
- Bt/Ht Maize 3.2
- Ht Maize 3.2

- Bt Cotton 3.1
- Bt/Ht Cotton 2.6
- Ht Cotton 1.5

Biotechnology Can Add Value to Global Agriculture

Biotechnology has a positive environmental impact, i.e. decreasing the use of pesticides. Biotechnology also makes it possible to reduce losses from pests and diseases, improve nutrient efficiency, and improve productivity.

The case of cotton:

Cotton is a major crop in China, South Africa, India, Egypt, and Indonesia. In India, 60 million people are dependent on cotton. Losses due to bollworm (a common pest) cost $1.5 billion in India and China. The cotton crop uses 50% of the total pesticides.

Conversely, 2 million gallons of pesticides were saved in the U.S. alone using Bt cotton.

The impact of a single GM crop in the developing countries: Bt cotton

In China, insecticide usage decreased by 67%, yields increased by 10%, and farmers saw income gains of $500 per hectare. Similarly, in India, insecticide usage decreased by 50%, yields increased by 40%, and farmers saw income gains from $75 to $200 per hectare (Source: Isaaa.org).

Benefits of Biotechnology

The post-harvest quality of foodstuffs can be increased with the use of biotechnology, prolonging the shelf life of fruits, vegetables and flowers. The crop area and season can also be extended. In addition, Bt crops have greater stress tolerance for problems like drought, acidity, salinity, heat, and flooding.

Enhancing Food and Agriculture

Biotechnology can improve agricultural production in the following ways:

- Producing more nutritious food with low toxins.
- Incorporating pharmaceutical proteins.
- Helping to clean up the environment.
- Creating industrial, value-added products.

Why Biotechnology?

A quick summary of the reasons to use biotechnology:

- Expedient
- Knowledge-based approach
- Offers unique solutions
- Integrates technology delivery
- Scale neutral
- Does not displace traditional methods
- Environmentally friendly
- Portable, can be used across crops
- Versatile, has an impact on all facets of food chain from producers to consumers

How Can Biotechnology Help Developing Countries and Resource-Poor Farmers?

Biotechnology has the potential to improve food nutritionally, for example increasing iron and vitamins in a food, as well as drastically increasing crop productivity and production efficiency. Crop damage and food loss has also shown to be reduced with the introduction of biotechnology. Furthermore, GM foods offer the possibility of reducing pollution of pesticides and other herbicides in the environment. For developing countries in particular, biotechnology empowers the rural sector through income generation and reduced economic inequity. Biotechnology can and should be used to promote sustainable agriculture in LDCs.

Some examples of foods that have benefited from biotechnology are:

- **Rice – The Miracle Food**
  Rice is the most important food crop in the world. Three point eight billion people consume rice on a regular basis worldwide. Rice farms are small, consisting of less than two acres on average. Only 6% of rice is traded in the world market. Much more rice is needed to combat famine and starvation. It is estimated that 60% more rice is needed by 2020, with less land, water, labor and chemicals to be available by this time. Current yield losses are estimated to be around 220 million tons.

- **Golden Rice**
  Milled rice has no beta-carotene, which is a source of Vitamin A. Two hundred million women and children have Vitamin A deficiency. As a result of this, about 500,000 children go blind (60 every hour), and 2 million children die every year. Golden rice is a strain of rice produced through genetic engineering that has been modified to produce enzymes for beta-carotene. Golden rice may provide one of the solutions to this problem, but we are still many years away from making it a reality. Neither golden rice nor "golden rice 2," introduced in 2005, are yet available for human consumption.

- **Sweet Potato**
  Sweet potato is the fourth largest crop in the developing world. It is an excellent source of calories, vitamins and minerals. It is commonly grown by resource-poor farmers and is very hardy.

- **Cassava**
  500 million Africans eat cassava on a regular basis. It was the first food crop in Africa and of great importance for subsistence farmers. It is very productive and drought-tolerant. Cassava is also rich in calories and cyanogenic glucosides. However, the African Cassava Mosaic Virus is devastating the crop today. The International Laboratory for Tropical Agricultural Biotechnology (ILTAB) at the Danforth Plant Science Center is currently working on research on cassava (as well as rice and tomato) to help improve sustainable agricultural production.

- **Papaya**
  Virus-resistant papaya grown in Hawaii is the only GM whole food grown now in the USA and the only product so far from the public sector.

Constraints to Biotechnology Development and Assimilation in Developing Countries

Some limitations of Bt development/assimilation in LDCs include:

- Finance
- Technical capital
- Infrastructure
- Ambivalent policies
- Trade issues

If Europe Adopted GM Crops

If Europe adopted biotechnology methods, research shows that nine GM crops could increase yields in Europe by 8.5 billion kilograms per year. In addition, GM crops would increase grower net income by EUR 1.6 billion per year. Finally, pesticide use could be reduced by 14.4 million kilograms per year compared with existing practices (Source: NCFAP.org).

Current Famine in Southern Africa and the WFP

Nearly 13 million people in 19 African countries are facing severe hunger and starvation, with about 300,000 facing death. The World Food Program (WFP), the United Nations international food organization, distributes food commodities to support development projects, to long-term refugees and displaced persons and as emergency food assistance in situations of disaster. However, recent criticisms of the WFP, and in particular U.S. aid, suggest that the U.S. has used food aid to introduce GM foods throughout the world, perhaps so that the European Union, where there is little market for GM foods, can be persuaded to adopt them. There have been instances of refusal of aid on this basis.

Why So Much Public Anxiety with Biotech Crops?

Societal concern about biotech is understandable! A strong assurance of the safety of Bt foods is needed. People are unfamiliar with the technology and there is a lack of reliable information circulating. This, along with opposition by activist groups and negative media opinion leads to a mistrust of the Bt industry. People are unaware of the safeguards that are incorporated into Bt foods. Some of the main societal concerns about food biotechnology are food safety, the environment, socio-economic impact, corporate control, and ethical questions.

Major Barriers to Agricultural Biotechnology

Some of the major obstacles to putting agricultural biotechnology to use are:

- Regulatory environment
- Trade barriers
- Public perception
- Environmental activism
- Negative media portrayal
- Food industry and retailers
- Organic food industry

Global Regulatory Environment

The global regulatory environment has fairly hostile policies toward biotechnology. Their focus tends to be less on science and more on precaution and politics. The regulatory apparatus are expensive, costing about $20 million, and employ complicated procedures that have not always been accurate in the past. For example, there have been problems with duplication of data. This is a huge administrative burden. This negative regulatory environment has contributed to the formation of a weak public sector capacity for producing biotech foods.

Impact on Research and Product Development

The impact of the global regulatory environment has meant fewer products in the pipeline for agricultural biotechnology. There has been an exodus of companies from Europe, where the public opinion towards Bt foods is particularly negative, and reduced funding for research worldwide. Only "blockbusters" are supported, larger players who favor large crops. There are few to no products emerging from the public sector, the area of a nation's economy that is tax-supported and under government control.

Developing Countries Have Much to Lose from the Current Biotech Fears
Promoting Food Biotechnology

Some of the necessary prerequisites for food biotechnology to increase aid to LDCs are:

- Enabling policies
- Harmonization of regulation
- Science-based regulation
- Address trade barriers
- Increased R&D funding
- Education and outreach

Is Biotechnology the Sole Answer to Global Food Problems?

It is important to remember that there is no single solution that can be a panacea or "cure-all" to global food problems. There are a myriad reasons for world hunger and starvation. Agricultural biotechnology is only one tool, but it has the potential to help and even save a great number of people. Biotechnology can only work when used with other traditional approaches to farming.

GMO and the social doctrine of the Church GMO: threat or hope?

Gonzalo Miranda, L.C

Dean of the School of Bioethics,
Pontifical Athenaeum Regina Apostolorum

1. Introduction

It is neither the responsibility nor the mission of the Church to take a stance on technical issues involving GMOs. Nevertheless, the subject matter also covers an entire series of ethical and social problems that must be considered from the standpoint of general ethical principles and criteria. In fact, whenever an assessment is made of the ethical validity of the use of GMOs, the backdrop always consists of a given anthropology and a vision of nature and the role which man must play therein, as well as ethical duties as these relate to the risks and benefits of human behavior, etc. An ethical analysis performed outside of any anthropological or cultural horizon runs the risk of being carried out within a horizon that is not focused, with the unfortunate result that the analysis would be based on assumptions never criticized or confirmed.

The social doctrine of the Church has developed, for a number of years now, its own methodology for the analysis of socio-political, technological and economic problems, focusing on them from the perspective of a series of guiding principles and criteria.

The new issues involving new biotechnologies and GMOs lend themselves to the application of this methodology and must be analyzed from an ethical and social standpoint.

As happens with so many forms of human behavior, the use of GMOs may be viewed both *intrinsically* and *extrinsically*. The first approach regards the ethical worth of a form of behavior in and of itself, examining the object of the act, meaning that which is done; the second, on the other hand, refers to the possible consequences of the act, or circumstances that would appear to have an effect on its moral value.

2. The intrinsic morality of GMOs

There are people who are convinced that the genetic manipulation of living beings is, on account of its very object, an ethically unworthy act, given that it aims to alter what is "natural". They contend that nature must always be held in absolute respect: *"Nature and everything that is natural is valid and good in and of itself; all forms of genetic engineering are unnatural and run contrary to nature, interfering with it […]; all forms of genetic engineering, therefore, are intrinsically bad."*[1]

1 Cf. Reiss M.J. – Straughan R., *Improving nature? The science and ethics of genetic engineering,* Cambridge University Press, Cambridge 2001[4], p. 60.

At times this vision is presented as a religious type of consideration: new biotechnologies interfere with the work of God, who created nature. But these considerations are not always formulated from a religious standpoint.[2] In the final analysis, the outlook is primarily an anthropological and cosmic one.

The anthropological vision of the Catholic Church leads to different conclusions. As we know, all reflections and doctrine of the Church draw their inspiration from the texts of the Sacred Scripture, considered by Christians to be the revealed word of God.

In the first pages of the Bible, the Book of Genesis presents the work of God the Creator and the role he assigns to man within the creation. One of the realities created by God is the human being. He belongs to the nature and the cosmos as a whole. At the same time, however, man was created as a being superior to all the other visible creatures. The first chapter of the Book of Genesis presents his creation as the end and completion of a progressive process: from the initial chaos to the human being. In fact, it is only with regard to him that God says: "We make man in our image, in our likeness" (*Gen* 1, 26). The Creator wished to create living beings similar to himself, capable, as is He, of seeing that the things created "were good"; in other words, capable of discerning the value and the meaning of those realities that represent Good in and of themselves. He also wished to create man with a capacity for understanding nature and the laws of nature, and for intervening to modify beings, both living and non-living, in order to defend against the dangers they present and obtain certain benefits.

In this sense, God made Man the "Gardener of Creation", charging him with "cultivating and caring for" all things created in a responsible manner.

The Vatican II Ecumenical Council concluded, "Man is right to hold himself superior to the entire universe of things, on account of his intelligence, with which he partakes of the light from the mind of God." And, immediately afterward, it acknowledged the progress made "through the impassioned exercise of human intelligence throughout the centuries" [...] in the empirical sciences, in technical fields and in the liberal disciplines."[3]

Slightly further on it is stated that "Christians [...] would never dream of pitting the products of human intelligence and Man's courage against the power of God, as if the rational creature could be a rival of the Creator; on the contrary, they are certain that the victories of mankind are a sign of the greatness of God and the fruit of his ineffable design."[4]

Along the same lines, Pope John Paul said that, "In the delicate field of medicine and biotechnology, the Catholic Church in no way opposes progress."[5] On the contrary, "Science and technology are a marvellous product of human creativity, which is a gift of God, seeing that they provide is with magnificent possibilities, which we benefit from with grateful souls."[6] It is for this reason that Christians, "as believers in God, who has judged the nature that He created to be good, benefit from the technical and economic progress that Man, through his intelligence, manages to achieve."[7]

---

2 Cf. Reiss M.J. – Straughan R., *Improving nature? The science and ethics of genetic engineering*, Cambridge University Press, Cambridge 2001[4], p. 60.

3 Con. Ecum. Vat. II, Pastoral Constitution, *Gaudium et spes*, 1965, no. 15. Hereinafter, *GS*.

4 *GS* no. 35.

5 John Paul II, *I appeal to the world of medicine: let nothing be done against life*, in *Teachings of John Paul II*, Vatican Publications, Rome 1986, pp. 1732–1736.

6 John Paul II, *The responsibility of science and technology. Speech of 25 February 1981, Hiroshima (Japan)*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1981, pp. 540–549.

7 John Paul II, *Man cannot be sacrificed to machines. Speech in Ivrea, 19 March 1990*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1990, pp. 692-698.

With regard to technical developments in the field of agriculture, he stated that the Church appreciates "The benefits that are drawn – and that it will be possible to draw in the future – from the study and application of molecular biology, complemented by other disciplines, such as genetics and its technological applications in agriculture and industry."[8] In fact, "Technology could represent, when applied correctly, a valuable tool for resolving grave problems, starting with hunger and sickness, through the production of more advanced and resistant varieties of plants, as well as valuable medicines.[9]

But Man must not forget that "his capacity to transform and, in a certain sense, create the world through his toils [...] is always carried out against the backdrop of the original donation of all things by God." Man must not "arbitrarily do what he wants with the world, subjecting to his will without reserve, as if it had no original form of its own and no earlier destiny decided by God, which Man may, yes, develop, but never betray. When Man behaves in such a way, rather than serving as an assistant to God in the work of creation, he takes the place of God and sets off a rebellion on the part of nature, which winds up being tyrannised rather than governed by Man."[10]

If, on the other hand, Man intervenes without abusing or damaging nature, then it can be said that, "he intervenes not to modify nature, but to help it develop, in accordance with its essence, meaning that of creation, which reflects God's will. Researchers working in this obviously delicate field endorse God's design. God wanted man to be the king of creation."[11] In the final analysis, it is God Himself who offers Man the honour of contributing with all the force of his intelligence to the work of creation initiated on the first day the world came into being.[12]

3. The extrinsic morality of GMOs

As I mentioned earlier, in carrying out an ethical analysis of human behavior, consideration must also be given to the way in which that behavior is carried out, the circumstances and, most importantly, the consequences of the behavior.

The Vatican II Council noted that, "The more the power of Man grows, the more his responsibility, both individual and collective, extends and broadens."[13] And the Pope stresses that, "We know that this potential is not neutral: it may be used either for the progress of Man or for his deterioration."[14] This is why, "it is necessary... maintain a prudent attitude and weigh with an attentive eye the nature, ends and means of the various forms of technology applied."[15] Scientists, therefore, must "truly place their research and their technical capabilities at the service of humanity,"[16] exercising them in

8 John Paul II, *May human wisdom always accompany scientific research. Before the Pontifical Academy of Science, 30 October 1981, Vatican City*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1981, pp. 330-338.

9 John Paul II, *Science must contribute to the genuine progress of Man. To the participants in the Congress promoted by the National Academy of Science for the bicentennial of its foundation, 21 September 1982*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1982, pp. 511-515.

10 Cf. John Paul II, Let. Enc. *Centesimus annus,* 1991, n.36.

11 John Paul II, *Genetic manipulation that reduces the life of Man to an object is arbitrary and unjust. To the World Medical Association, 29 October 1983*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1983, pp. 917-923.

12 Cf. John Paul II, *Genetic manipulation that reduces the life of Man to an object is arbitrary and unjust. To the World Medical Association, 29 October 1983*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1983, pp. 917-923.

13 *Ibidem*.

14 John Paul II, *The Responsibility of Science and Technology. Speech of 25 February 1981, Hiroshima (Japan)*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1981, pp. 540-549.

15 John Paul II, *Man cannot be sacrificed to machines. Speech in Ivrea, 19 March 1990*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1990, pp. 692-698.

16 John Paul II, *Experimentation in biology must contribute to the overall good of man. To the participants in a conference at the Pontifical Academy of Science*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1982, pg. 889.

accordance with "principles and moral values that fully respect and satisfy the dignity of Man."[17]

In this sense, the formidable potential of biological research is a source of deep-rooted concern, seeing that, quite possibly, "we are not yet able to measure the disturbances caused to nature by *indiscriminate* genetic manipulation and *unbridled* development of new species of plants and forms of animal life, to say nothing of the unacceptable interventions regarding the very origins of human life."[18] In fact, "It has been observed that the application of certain discoveries in the fields of industry and agriculture produces, over the long term, negative effects. And so there can be no ignoring the fact that, whenever an initiative is taken in a given area, its consequences in other areas, as well as on the general well being of future generations, must be weighed"[19].

With these warnings in mind, I feel it is safe to say that the intervention of man should be condemned when it upsets, damages or injures living beings or the natural environment.

On the other hand, it should be praised when it leads to further perfection and improvement. This is the judgment that should be passed on to work meant to inhibit the production of toxic substances by certain plants, or to make these same plants more resistant to a shortage of water or to the salinity of certain soils; equally positive are advances thanks to which organisms defend themselves from certain viruses, bacteria or insects that gravely damage them; and this is also true for all alterations that manage to reinforce the qualities of food products or even give foods the capacity to improve the health of individuals.

4. A number of recommendations

Within the complex reality of the research, production, marketing and distribution of GMO, we can arrive at a number of recommendations based on the principles and criteria of judgment that underlie the social doctrine of the Church.

a. Evaluation and management of risks

As in the case of any human activity, a responsible, prudent attitude must be taken with the evaluation of any toxic effects of certain GMO products (as well as other products of traditional agriculture or results of classic genetic technology). At the same time, thought must be given to managing the risks that the dissemination of these organisms might pose for the delicate balances of the ecosystem.

Logically, it is best to keep in mind that there are few human activities which entail absolutely no risk, and that risk cannot be assessed and managed in generic terms, much less on an a priori basis; what is needed is case by case evaluation and management. At the same time, when assessing the importance of a given risk, a comparison must be established with any foreseeable benefits.

---

17 John Paul II, *Experimentation in biology must contribute to the overall good of man. To the participants in a conference at the Pontifical Academy of Science*, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1982, pg. 889.

18 John Paul II, *Peace with God the Creator, Peace with all of Creation*. Message for World Peace 1990, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1989, pp. 1463-1473.

19 John Paul II, *Peace with God the Creator, Peace with all of Creation*. Message for World Peace 1990, in Idem, *Teachings of John Paul II*, Vatican Publications, Rome 1989, p. 1465 (my underlining).

b. Justice and equity

The social doctrine of the Church established as the founding principle of human behaviour (both individual and collective) a respect for justice and equality (it is no accident that the ministry where this encounter is being held is called *Iustitia et Pax*, while the motto of the newspaper published by the Holy See, the *Osservatore Romano*, is: *"uniquique suum"*).

The Church acknowledges the just role of profit in the operations of businesses.[20] The Vatican II Council further noted that "[...] there is a tendency, and justly so, to increase the production of goods in agriculture and industry, as well as the performance of services," so as to favour "every possible contribution to this development."[21] But it adds that, "the ultimate and fundamental goal of this development is not merely to increase the goods produced, nor to seek profit or economic control, but rather to serve man, [...] every man [...] and every human group, no matter what the race or continent."[22]

This consideration demonstrates the critical importance of promoting criteria of justice and equality between the rights of researchers and producers and those of consumers and farmers. What is needed are measures designed to avoid possible abuses of monopoly positions and excessive concentrations of power. An adequate integration between the public and private sectors can prove to be helpful in this sense.

It is also important to favour wide-ranging and correct information that promotes informed participation by citizens in decisions regarding GMOs, given that the consequences have an effect on everyone. The labelling and tracing of these products can contribute to establishing transparency in this sector, which is important for us all. Heightened awareness in this area might even contribute to improving transparency and control with regard to other foodstuffs that are not genetically modified.

c. Solidarity

The Church urges that efforts go beyond mere justice and equity, consistently ravelling and renewing the path of solidarity, which should be an international concern (as in the exhortation of John Paul II to "promote the globalisation of solidarity").

It is important to avoid falling into the trap of believing that the spread of the benefits tied to GMOs alone will be able to resolve all the urgent problems of poverty and underdevelopment that plague so many parts of our world. Many other approaches must be attempted, maintained or renewed in order to promote true and lasting development of the most backward countries.

On the other hand, if GMOs represent a genuine opportunity to favour the development of all countries, and especially the most disadvantaged ones, then the demands of solidarity make it our moral duty to ensure that they are adequately distributed in each local reality. Blocking them on an a prior basis, on account of merely ideological stances and hidden economic interests would not only reveal a lack of solidarity, but also represent a grave injustice.

---

20 Cf. John Paul II, Let. Enc. *Centesimus annus,* no.35.

21 Vatican Council II, Const. Past. *Gaudium et spes*, no. 64.

22 *Ibidem.* Cf. *Catechism of the Catholic Church*, nos. 2424 and 2426.

Solidarity must facilitate not only the exchange of genetically upgraded seeds, but, even more importantly, communication of the technology needed for in loco development of the products that prove best suited to each place and situation. Exchanges of scientific and technological knowledge, transfers of technology towards developing countries, the education and training of agents able to render these countries self-sufficient: all these factors are genuine expressions of international solidarity.

Finally, as the social doctrine of the Church has always stressed, the solidarity of the affluent countries must be matched by the responsibility of the developing countries, starting with their government leaders. It is they who should take the lead in assessing the risks and benefits of GMOs; and, if they decide that their people stand to benefit, then they should be the first to promote research, control and proper distribution of these potential benefits for their countries.

5. Conclusion

In these last few days, we have once again been brought face to face with the complexity of the issues we have gathered here to discuss.

The Church does not presume to teach biology to biologists, economics to economists or politics to politicians. The Church is simply doing its best to understand and to critically ponder the complex data offered by the experts. On the strength of its millennial traditions, on the strength of its intensive vocation in favour of mankind, enlightened by the Word that Christians believe to be the Word of God, the Church attempts to understand, to throw light on the issues from a perspective of anthropological knowledge that places Man at the centre of Creation, as the being responsible for its safekeeping and cultivation.

The Church holds a deep-rooted belief in the greatness of Man, created in the image and likeness of God. And one manifestation of this greatness is the fact that Man, unlike the other living beings, agonises over the morality of his behaviour, as in the case of the use of GMOs, asking himself whether such practices pose a threat or represent a hope.

And the fact that we do not respond to this question with indifference, as shown by our gathering, constitutes, in and of itself, an important sign of hope.

GMOs and Science: What Have We Learned

Peter H. Raven

Pontifical Academician;
Director, Missouri Botanical Garden, St. Louis, Missouri

It is my pleasure today to present a summary of current scientific views of the potential positive and negative effects of genetically modified organisms (GMOs). My comments will be based primarily on the "Study Document on the Use of Genetically Modified Food Plants" to Combat Hunger in the World (Pontifical Academy of Sciences, 2001), also taking into account the statement by the academies of science of Brazil, China, India, Mexico, the United Kingdom, the United States, and the Third World Academy of Sciences published on their behalf by the Royal Society in 2000. These are summary consensus documents that represent well the views of the world scientific community on the issues involved, and they are in agreement with other studies published over the past 30 years.

The explosive growth of the human population from 2.5 billion people in 1950 to 6.3 billion today, coupled with the desire by people around the world to achieve higher standards of living (more consumption) and the use of often unsuitable technologies has resulted in the loss of 20% of the arable land that was available in 1950, and nearly 20% of the topsoil. Some 700 million people, about equal to the combined populations of Europe, the United States, and Japan, are literally starving, receiving less than 80% of the UN-recommended minimum caloric intake, and therefore unable to experience proper brain development as infants or maintain their body mass as adults. As much as half of the total population of the world is malnourished with respect to one or more essential nutrients. Half of the global population consists of people who are living on less than $2 per day. Thus there is an urgent need to achieve higher levels of productivity in agriculture everywhere to help alleviate these problems. Any effort to deny access to technologies that are demonstrably helpful in feeding the people of the world must for this reason be judged from a moral and ethical point of view in relation to its real, not imagined, effects on human welfare.

It is important in this connection to realize that we are estimated currently to be consuming the productive capacity of our planet at 120% of its continuing output. Some 55% of total net terrestrial photosynthetic capacity is currently being used, wasted, or diverted by human beings; in addition, we are consuming an estimated 45% of the total sustainable supplies of fresh water. Our demands for water, about 90% of it used for agriculture, are growing rapidly, while the water table is dropping precipitously across wide areas of north China, India, and elsewhere. For these reasons it is predicted that about half the human population, some 3.5 billion people, will be living in regions facing severe water shortages by 2025. We therefore must find improved crops that can tolerate drought better than the strains we cultivate now.

Overall, it is estimated that at least two billion additional people are likely to be added to the world population before it can reach stability, and some of the societies

in which individuals consume the most are advocating population growth again now. For all of the countries of the world at their present population levels to reach the current standard of living of the industrialized countries would require the productivity of approximately two additional copies of the planet Earth. All of this must, therefore, be judged against the background of a world in which a sixth of us are starving, and half of us are malnourished and living in extreme poverty, with at least two billion more people being added over the next few decades and expectations for even greater levels of consumption endemic to human beings everywhere. Those who sidetrack new and helpful technologies on the basis of fanciful and sometimes self-serving arguments must therefore be judged in the light of the effects of their arguments on people everywhere, and not simply on the rich societies where most of those who protest the use of modern technologies enjoy lives of abundance. Colorful and threatening terms such as "contamination," "release," and "spillage" have been applied to the cultivation and dissemination of such crops, not to mention even less reasonable ones, such as "Frankenfoods" and "Terminator Genes," but these terms, which reflect a lack of logic and careful consideration, have no place in rational discourse.

In the following remarks, I shall concentrate on scientific questions but also address some related considerations briefly as a part of my presentation.

First, I would like to mention that questions concerning the acceptance of genetically modified organisms (GMOs) and the problems that they might pose have been taken seriously ever since the development of recombinant DNA technologies 31 years ago (1973). Following conferences and consultations by the leading molecular biologists, careful containment of the first organisms produced by the transfer of genes from one unrelated kind of organism to another, and detailed examination of the results in hundreds of laboratories throughout the world, it has become clear that there is nothing intrinsic to the process of genetic modification by the production of transgenic organisms that makes them unsafe in any respect. Like the many other methods that have been used to modify crops since the dawn of agriculture some 10,500 years ago, transgenic methods must be judged on the basis of their products, and not the methods by which they were produced. Idiosyncratic arguments are sometimes presented by those arguing against the adoption of GMOs, presumably for social or other reasons, but the facts reviewed by thousands of independent scientists throughout the world for three decades make this point as certain as any scientific conclusion can be. We should not therefore conduct our discussions of this matter in an atmosphere of murky, imagined threats, but rather in the light of world scientific consensus as to the safety of the methods involved. There is simply no justification for regarding imprecise traditional methods of transferring genetic traits as safe, but modern precise ones as unsafe, and we must move forward from that point as rapidly as possible.

Secondly, concerning the use of GMOs to produce food, there is no theory or set of theories that contradicts the generally accepted conclusion that those currently in use are safe as food for human beings and domestic animals, and no single case of illness resulting from consuming foods produced by GMOs, even though billions of people throughout the world use them regularly. Most beer and cheese consumed worldwide is made with the aid of GMOs, as are hundreds of different medicines. As in the first point, arguments about the lack of safety of these foods are apparently ideologically driven, lacking a factual basis. Obviously it would be possible to produce a poisonous food with the help of gene-splicing techniques, but who would do this or put it on the

market? No foods consumed by human beings are tested as extensively as those produced by GMOs, and there is no evidence of any lack of safety in such foods. To discuss these questions on the basis of an imaginary threat to human health is misleading and ought not to be acceptable to the members of a rational society.

Third, the ecological effects of GMOs differ according to the properties of the individual transgenic organism. Gene flow between species is a regular feature of most groups of plants, and, depending on the pollination systems of the groups involved, may extend over long distances. Studies recently reported by the U.S. Environmental Protection Agency have demonstrated the Roundup Ready genes in bentgrass can be disseminated more than 20 km to natural populations. When wild or weedy relatives of GM crops grow near them, it can be assumed, and has been widely demonstrated, that gene flow is likely to occur. Consequently, the transgenes introduced into the crops are likely to be present in some or many of their relatives, the proportion depending on the selective advantage of that particular gene in the wild or weedy populations. But then what? It all depends on the role of the transgenes in the wild or weedy populations. If they are resistant to a particular herbicide, would that in itself be harmful? Would the ability to produce natural insecticides make them more serious weeds? Are they likely to harm natural communities in some unknown way? The kinds of questions we should be asking would be along the lines of "what if the wild relatives of sunflower in the United States produced an insecticide? What then?" rather than, "did the genes escape?" And "Could any kind of maize survive in nature?" not "What will genetically modified maize do to natural habitats where it is grown?" Is the spread of genes from GM bentgrass worse than the spread of other genes from cultivated plants that has been going on for some 10,500 years? To create such a straw man flies in the face of logic: it all depends on the particular characteristics, and not on how they reached the plants in which they occur.

There is no ecological theory that supports the idea of wild plants acquiring a transgene and then wrecking havoc in a natural community, but plenty of examples of introduced, invasive plants that have not been genetically modified playing such a role. While common sense must be a guiding principle, it is not logical to imagine consequences that have never been observed at the cost of denying people access to food or adequate economic return for their efforts. Simply to repeat the claim that widespread problems are likely to occur, or that the operation of nature is so mysterious that we can never know what will happen denies logic and flies in the face of the available facts at the cost of hungry people who deserve better treatment from those of us who are so much more fortunate than them.

I have spent my life in fostering efforts to understand biodiversity and to conserve it, and in helping to build capacity for sustainability in developing countries around the world. I therefore find it most distressing that the very techniques that could spare biodiversity and feed hungry people are so often being retarded for illogical and selfish reasons. It is unquestionably true that the development of crop agriculture, along with the domestication of animals, which began about 10,500 years ago in the eastern Mediterranean region, has been and remains extremely negative for the survival of biodiversity. The areas devoted to agriculture and grazing have grown as the human population exploded to its present 6.3 billion. Some 11% of our planet's surface is devoted to the production of crops, and an additional 20% is grazed, usually unsustainably. The "cleaner" the agriculture is, the worse it is for biodiversity.

None of this in itself has anything to do with the particular genetic methods used to produce the crops, although the less land that can be cultivated for an equivalent amount of production, the better for the survival of biodiversity in adjacent areas. Nothing is more destructive to biodiversity than widespread, low-yield, traditional methods of agriculture, and it is highly misleading to romanticize them, as if all were in harmony before there were so many of us that agriculture was intensified. The extinction by Polynesians of about 1,000 species of birds (about a tenth of the world's total bird species) on the Pacific islands, along with an unknown number of other kinds of organisms, during a period about 1,200 years, offers one kind of solid evidence to the fact that all agriculture (combined in this case with hunting) is highly destructive to biodiversity. If the world's population is to be fed well, and starvation is be alleviated for the hundreds of millions of people who are suffering now, agriculture must become more productive. The development of GM crops, with precisely determined characteristics that make them survive well in the extremely diverse places that they are grown promises major increases in productivity and a greatly enhanced ability to preserve biodiversity.

As to the reduction of diversity in the crops themselves, that is a long-term process that has little to do with the application of current methods. It is often argued that GM methods are suitable only for large-scale agriculture and that their introduction has led to the reduction of variety in the crops, but that is simply not the case. Certainly large farms tend to have less genetic diversity in their crops than an equal area occupied by small ones, but there is no logical connection between that observation and the use of transgenic methods to produce the crops. For example, more than 500 strains of soybeans in the United States, each adapted to a particular agricultural situation, have been genetically engineered, and the whole array of strains that was present initially, with all of its genetic diversity, is still being used commercially. There is no reason in principle why minor crops grown by small-scale farmers cannot be genetically modified to make them more nutritious, better able to grow in dry or saline habitats, or whatever else is desired, thus actually helping to maintain crop genetic diversity. If smaller amounts of pesticides are applied, the case with many GM crops, the survival of biodiversity will be enhanced; for example, an estimated 70 million birds are killed by pesticide applications on croplands annually in the United States alone! Lessening the use of pesticides will also help to alleviate the estimated 500,000 cases of sickness and 5,000 deaths around the world that occur annually now as a result of the indiscriminate use of pesticides. Despite heavy applications of pesticides, especially in Europe, there is an estimated global loss of $244 billion in crops per year, and the applications of these chemicals have serious negative consequences for the environment. In this connection, it has been estimated that if half the maize, oilseed rape, sugar beet, and cotton grown in Europe were genetically modified to resist their pests, there would be a reduction of about 14.5 million kilograms of formulated pesticide product applied, a savings of approximately 20.5 million liters of diesel, and the prevention of the emission of 73,000 tons of carbon dioxide into the atmosphere. Clearly, we must develop new productive, low-input systems of agriculture, a strategy that would involve the modification of many current practices. These efforts will be aided substantially by modern genetic methods. Cotton is already a global success story, and those who cultivated GM cotton are clearly better off than ever before.

In view of these considerations, it is remarkable that the major negative finding of the British study of GM crops reported in 2003 was that biodiversity was lower in the

fields where GM crops were grown – because weed control was more effective there! No college of agriculture in the world teaches that it is better for productive agriculture to include more weeds, and very few places – certainly none where hungry and needy people live in the developing world – have the luxury of managing their primary fields in such a way as to encourage anything but productivity. If all of the agriculture in the world were run in such a way as to encourage weeds, there would be many more starving people, a situation that we should very much wish to avoid. Concentrating agriculture as much as possible in highly productive lands and encouraging biodiversity in uncultivated lands managed in other suitable ways is the path that we logically should follow.

As Per Pinstrup-Anderson, a leader in efforts to feed the hungry and poor people of the world, has put it, it seems natural to people in Europe and other more developed regions to use medicines produced through genetic modification, but to a mother in a famine-struck region of Africa, the disease she and her children suffer from is hunger and the cure is food. The efforts of organizations such as Greenpeace to block efforts to feed people adequately throughout the world by battling biotechnology resolutely are doubtless helpful to the finances of that organization, which does not spend a cent of its money to alleviate starvation or to help people, but they are outrageous, scientifically unfounded, and should be rejected out of hand by any moral person.

In our reports, we of the Pontifical Academy of Sciences stressed that it is a moral imperative for the fruits of all new technologies to be made available to all of the world's people, and more especially to those who are truly needy. Neither corporations nor wealthy nations have the right to block access to such technologies, and there is in fact a general willingness to encourage full access to them. The distribution is limited in part by the relatively small numbers of scientists in most developing countries, not much more than 10% of the world's total in the less developed countries, which include 82% of the world's people. This factor makes it difficult for many countries to evaluate on their own terms the fruits of scientific and technological advance in the rest of the world. All countries should develop their own standards for the evaluation of GMOs and other technologies, either nationally or regionally, and put in place regulations that will serve them properly in such matters. In these considerations, the matter of intellectual property rights must be considered carefully and not be allowed to block the access of the poor to modern innovations that can help to alleviate their condition. In addition, the application of transgenic methods to the many different systems of agriculture that are appropriate to different conditions around the world should be accelerated and treasured for the value that it promises. For example, the development of transgenic rice resistant to salt water using genes from mangroves, being carried out at the M.S. Swaminathan Research Institute in Chennai, offers great promise all around the shoreline of India, where the sea is encroaching on croplands for which the existing supplies of fresh water are inadequate. The development of protein-rich potatoes that is being pursued in India, China, and South Africa is but one example of a simple strategy that will serve well to help alleviate hunger and poverty. In general, public-sector research adequate to provide benefit for poor farmers in developing countries should be supported at a much higher level than is the case now.

World trade, which is one important element that will affect the way that the growing 6.3 billion of us learn to live together, can be an instrument for good or ill depending on how it is organized. World standards are required, as are mechanisms for reach-

ing agreements that benefit people everywhere. GMOs are one very small part of such trade, but one that has proven controversial and has been used in various ways to limit commerce. We must move to a period of reconciliation, one in which our common needs are taken into account, and not only on the basis of what is considered good in one region or another, but what the scientific and social facts may be. Doing so would allow a greater number of people to lead healthy lives that are worthy of we who live in rich countries. The drive to feed hungry people and to redress the morally unacceptable imbalances that exist around the world should take precedence over other considerations: in this case there are no valid scientific objections to utilizing these technologies with due consideration to the implications of each new proposed transgenic crop for the environment.

In conclusion, one might well ask why a general ban on GM foods and the cultivation of GM crops exists in Europe. In view of the lack of scientific evidence that such cultivation would be harmful, one can only conclude that the reasons for the ban are emotional, personal, and political. The major drop in genetic research in Europe over the past five years or so clearly has to do with this ban. Extended, it will continue to limit greatly the potentially important fruits of European research in this area and indeed to threaten the continent's economic development. Where does the gain for anyone lie in the perpetuation of this situation? Whatever policy might be adopted for Europe, persuading governments responsible for the lives of hundreds of thousands of starving people in Africa to forego food aid on the basis of politically or economically motivated disinformation seems to me to constitute a serious crime against humanity. I maintain that those responsible for this misinformation bear a responsibility for the lives of the people who are dying, and urge them to begin to deal rationally with the situation by allowing the fruits of human ingenuity to be applied to the solution of the extremely serious problem of hunger. Fortunately, India and China, as well as many of the countries in Latin America, have decided to utilized GM crops to improve their economies and the nutrition of their people, which leaves Africa and some countries of South East Asia, notably Thailand, left to be pushed hard by the European Community on the issue. It is important to keep in mind that all of this controversy is taking place without a single case of human or animal sickness or environmental problem anywhere in the world reliably attributed to GM crops!

If allegations that the European Union or individual nations are funding pressure groups such as Greenpeace or "The Catholic Institute for International Relations" (not affiliated with the Vatican, and perhaps not officially with the Roman Catholic Church) are true, they clearly indicate a misuse of taxpayer funds to support ideological causes that are unsupported and harmful to the development of Europe and its individual countries. It is exceedingly difficult to understand why public spokespeople such as former U.K. Minister Michael Meacher persist in making idiosyncratic and scientifically unfounded comments about this area. Such statements have affected a majority of European consumers and sadly led them to believe that great dangers are lurking somewhere in the practice of this particular kind of genetics. Their beliefs are doubtless sincere, but unfortunate for the future of European science and for the hungry people of the world. At any rate, for them to welcome the use of transgenic technology for beer, cheese, and drugs, while denying it to those in need of food, seems to me to be truly obscene. Loving people throughout the world in a truly Christian way demands much more of us in return for the privileges that we enjoy.

How Developing-World Farmers Have Used Biotech Crops

Carl E. Pray

Professor and Director of the Graduate Program
Department of Agricultural Food and Resource Economics
Rutgers University, New Jersey

The Issues
- Is there a need for GM crops?
- Have poor farmers in developing countries benefited from the adoption of biotech crops?
- Who captures most of the benefits?

Focus on Genetically Modified (GM) crops:
They are generating the most controversy, but:
- Tissue culture is producing disease-free planting material that is increasing banana & cassava production in Africa, Latin America, and Asia.
- Marker aided selection is producing improved, non-GM rice, pearl millet, maize, and other crops.

Structure of Presentation
- Farmer's benefits from insect resistant cotton in China
- GM food crops
- White maize in South Africa
  * Rice in China
- Who captures the benefits?
  * Small farmers?
  * Multinational biotech companies?

Insect Resistant Cotton in China:
Bt cotton introduced in response to pest problems
- Bollworms (H. armigera) are the main pest in Yellow River and are resistant to most insecticides.
- China uses more pesticide than any country in the world, spending $5 billion per year.
- Thousands of farmers are poisoned, with hundreds dying annually as a result.
- Cotton is the most pesticide-intensive field crop.

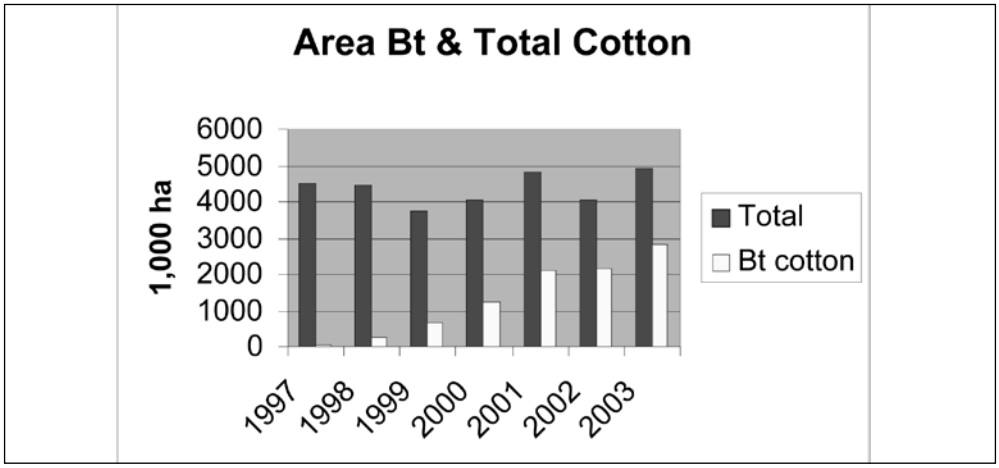
Development of Bt Cotton in Response to these Problems:

Chinese Academy of Agricultural Sciences Beijing
Bacillus thuringiensis (Bt) gene plus Cowpea Tripsin Inhibitor

Chinese transformation method
22 Bt cotton varieties, all provinces
Monsanto and Delta and Pineland
Tried U.S. and local varieties with Bt gene.
The U.S. Bt cotton varieties performed better.
Four Varieties were approved for four provinces.

In addition to the approved varieties:
CAAS Cotton Research Institute, Anyang, Henan
Released insect-resistant varieties using unidentified Bt.
Provincial Academies of Ag Sciences
Developing many Bt varieties back-crossing 33b into local varieties.

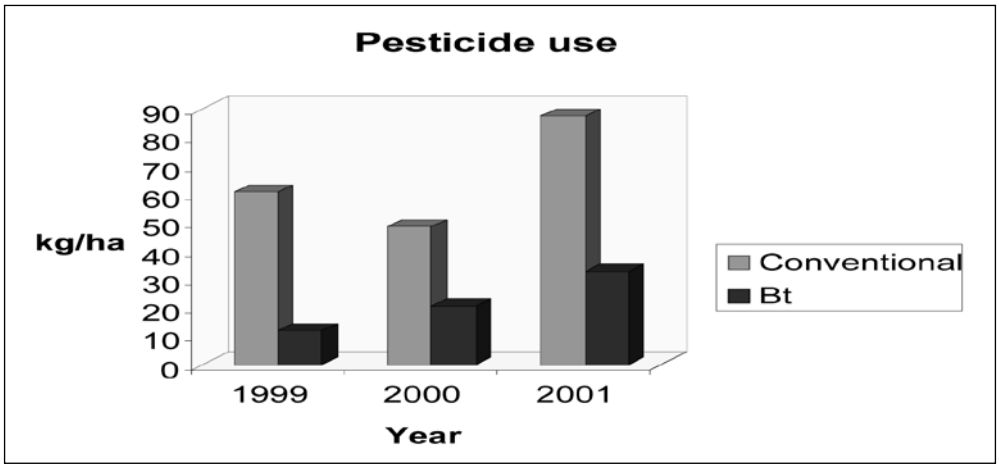
Bt Cotton Spreads Rapidly:



Adoption is based on farmer's decisions
- Small farms – about one hectare.
- Land is owned by the government. Farmers have 30-year lease and cannot sell the land.
- Farmers have been free to choose what crops they grow since 1984.
- The last production quotas on cotton were gone by the mid-1990s.
- Government procurement of all cotton until 1999 then gradually allowed for competition.

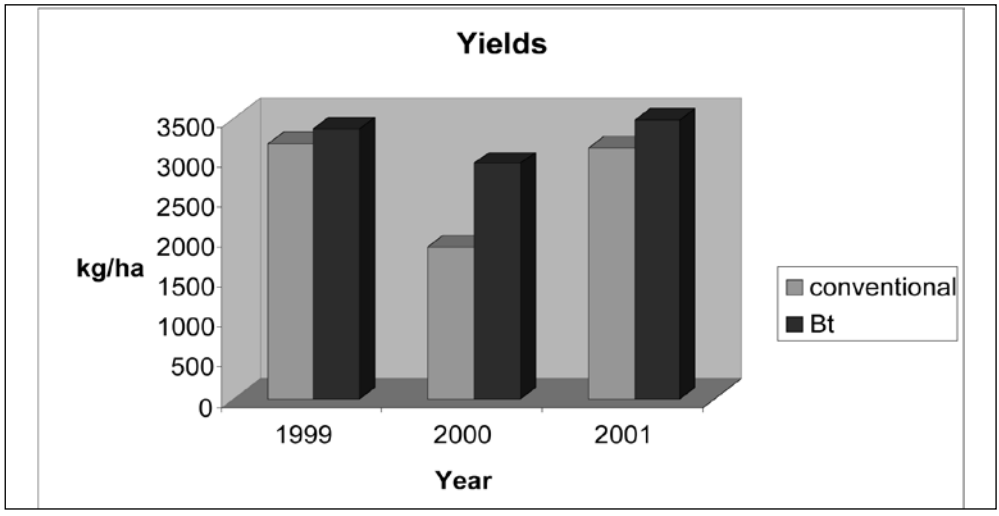
CCAP & Rutgers Survey Cotton Farmers
- CCAP (Center for Chinese Agricultural Policy)
- In the year 1999 surveyed 286 farmers in the Hebei & Shandong provinces.
- Stratified random sample—Monsanto and Chinese Bt, non-Bt cotton.
- In the year 2000, 400 farmers in Hebei, Shandong, and Henan were surveyed.
- In the year 2001, 366 farmers in Hebei, Shandong, Henan, Anhui, and Jiangsu were surveyed.
- Had to keep moving to find conventional varieties.

Pesticide Use Is Reduced



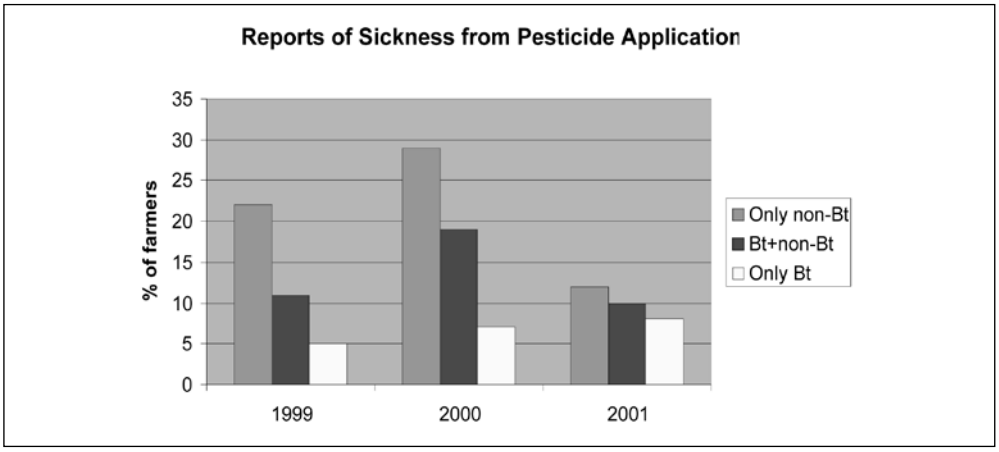
Yields Slightly Higher

Costs Down, Income Up (RMB/ha)



	1999		2000		2001	
	Bt	Non-Bt	Bt	Non-Bt	Bt	Non-Bt
Revenue	1362	1265	1578	1013	1277	1154
Total Costs	857	1117	1218	1159	1000	1379
Net Revenue	504	148	367	-182	277	-225

Pesticide Poisonings Down

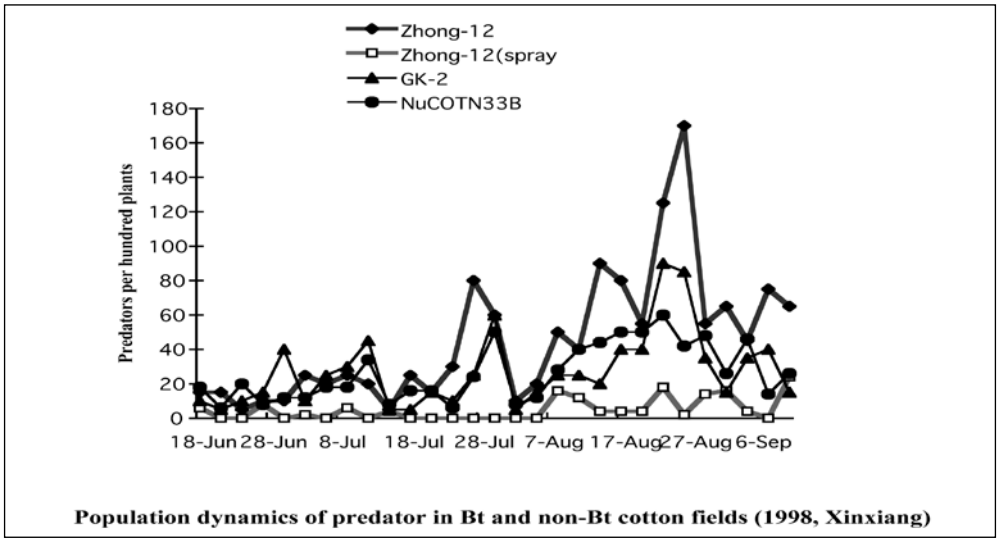


Impact on Environment

In China, a major reduction in pesticide has lead to a greater biodiversity of insects.

The Chinese Bt gene exists in at least 26 approved varieties and many more unapproved varieties; thus, agro-diversity probably has not declined.

Predator Density Increased in Bt Cotton in China



Source: Wu Kongming

No evidence of increase in bollworms resistant to Bt

Resistant bollworms probably will increase, but when?

- They have been monitoring bollworms in field since 1997, but there is no sign of increasing resistance yet.
- Institute of Plant Protection conducted special studies of potential hotspots, and there was no problem.

Subsistence Food Crops

There are four GM rice varieties in pre-commercial trials in China: two Bt varieties, one Cowpea Tripsin Inhibitor, and Xa-21 for disease resistance.

Bt white maize in South Africa is the only one grown extensively.

Bt yellow maize in Philippines is used mainly for animal feed.

History of GM Rice in China

GM rice research started in the late 1980s. In late 1997 and 1998 many traits were approved for environmental release:

- The Bt gene – stem borer and leaf folder resistant.
- The CPTi gene – stem borer resistant.
- The Bar gene – Basta/Liberty herbicide resistant.
- The Xa-21 and Xa-7 genes – bacterial blight and blast resistant.

There were field trials of salinity and drought resistant hybrids in the late 1990s.

Pre-production trials on farmers' fields were begun in 2002

Xianyou-63 with Bt gene, developed by Central China Agricultural University in Hubei:

- Old Hybrid – Hunan
- New gene – CAAS
- II-Youming-86 with CPTi gene, developed by Chinese Academy of Sciences and its collaborators in Fujian:
- New hybrid – Fujian
- New gene and promoter – CAS
- There is also another Bt and an Xa-21 hybrid.

Study Impact of GM Rice

CCAP team conducted survey on farmers growing GM rice in 2002 and 2003. Farmers were located in one village in Fujian and 7 villages in Hubei. Total sample: 370 plots of land on 178 farms.

Yield up slightly, pesticide down dramatically:

	2002			2003		
	Sample plots (n)	Yield (kg/ha)	Pesticide (kg/ha)	Sample plots (n)	Yield (kg/ha)	Pesticide (kg/ha)
Hubei						
GM Xianyou-63	38	6968	1.6	78	5949	1.7
Non-GM Xianyou-63	23	5968	25.7	9	5779	21.3
Non-GM others	44	6950	12.7	109	5911	19.7
Fujian						
GM II-Youming-86	4	7313	6.8	3	8250	8.2
Non-GM II-Youming-86	8	7186	31.8	4	5670	31.9
Non-GM others	13	5294	27.9	14	6362	36.8

Government has not yet approved commercial cultivation

The Ministry of Agriculture is in charge of approval process.

The Ministry of Health tests food safety.

The Ministry of Environment tests for environmental safety.

The Ministry of Agriculture is considering approval this spring.

Spread of Bt Maize South Africa

Table 2: Estimated area planted to transgenic crops

Crop	1999/2000	2000/2001	2001/2002	2002/2003
Bt Yellow Maize ha	50 000	75 000	160 000	197 000
% of yellow	3	5	14	20
Bt White Maize ha	0	0	6 000	55 000
% of white	0	0	0.4	2.8
Total Bt Maize ha	50 000	75 000	166 000	252 000

Source: SANSOR, Monsanto and own survey

Mean Yields Small-Holders in KwaZulu Natal

	Bt yield kg/ha	Conventional variety yield kg/ha	Yield difference kg/ha	Percentage difference
Simdlangentsha 2002/2003	782	667	115	17.3%
Hlabisa 2002/2003	891	762	129	16.8%
Hlabisa 2001/2002	1770	1210	560	46%

Assuming seed rate of 10kg/ha

Quality high – maize farmer Hlabisa

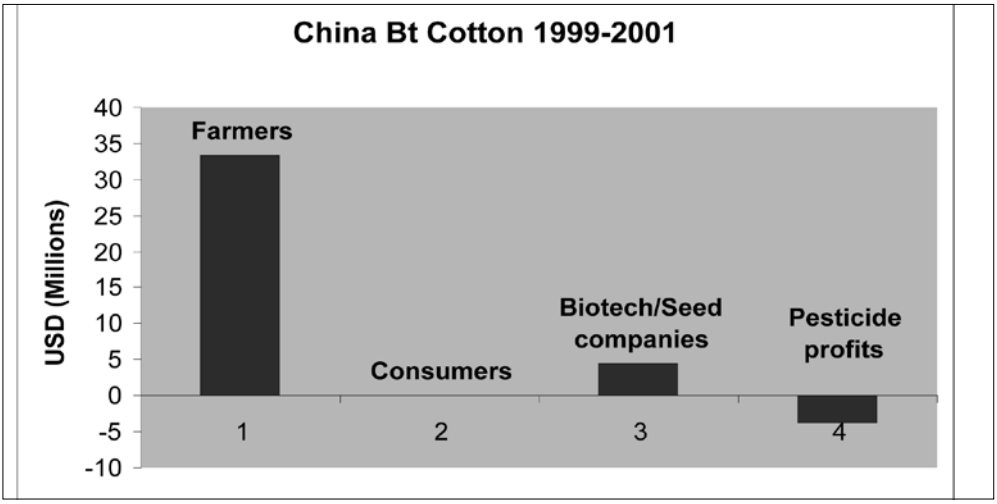
Pesticide use unchanged

Small farmers do not use much pesticide for stalk-borers – some granules.

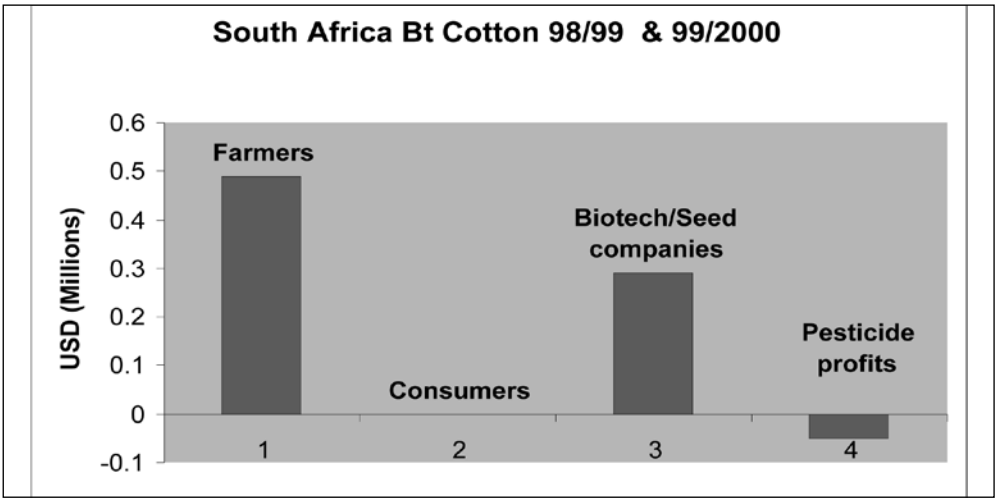
As a result, there has been little reduction in use due to Bt.

Who Captures the Benefits From GM Crops?

Bt Cotton with Weak Intellectual Property Rights – China



Bt Cotton with Strong Intellectual Property Rights – South Africa



Small vs. Large Farmers – North China 1999

	Bt as % of Observations	Yield Increase Kg/ha	Change in Net Income
Farm Size			
0.0–.47 ha	86	410	3331
0.47-1 ha	85	-134	3871
1+ ha	87	-124	1534
HH Income			
1–10,000	85	170	3151
10,000+	91	65	1301
Per Capita Income			
1–1,500	85	456	3702
1,500–3,000	83	8	2519
3,000+	97	-60	-125

South Africa: Small vs. Commercial

Bt cotton benefit distribution using data for 2000/2001

	Small farms	Commercial Farms	
	Dry	Dry	Irrigated
	Rand/ha		
Farmer benefits	367	194	356
See & biotech	82	117	285
Pesticide	-6	-23	-59

Conclusions:

- Poor farmers need better incomes and safer ways to grow crops.
- 5 million small farmers are benefiting from GM crops in China and many more in India, South Africa, Mexico and elsewhere.
- Most benefits go to farmers and not companies – even if there are strong intellectual property rights (IPRs).

Feeding a Hungry World: The Moral Imperative of Biotechnology

Edwin Y. Paraluman

Chairman, SARGEN Integrated Irrigators Federation
General Santos City, Philippines

I am the Federation Chairman of the farmers in our city, General Santos City in Mindanao, where I have 32 organizations under my leadership.

The Philippines is composed of 7,100 islands, during low tide. It is rich in natural resources, and has productive agricultural land for food production. That is the beauty of the Philippines.

The population of the Philippines in the 1950's was only 50 million, but now Filipinos number about 84 million. So our population is increasing fast. Every second, three babies are born. There is one less hectare of agricultural land every eight seconds, because it is used for urbanization, housing and land conversion. In our cities, the land is being converted into housing subdivisions. And I tell our mayors that we need agricultural production; we do not need buildings on our farms.

So our children are worried, because there is less food, we have less land, we have less water. They are worried about what they will eat in the future.

Modern biotechnology is one of the many ways to improve productivity. Healthy foods for consumers, protection of the environment and many potential agricultural improvements enhance food production. So we really need modern biotechnology in the Philippines.

BT Maize was the first use of biotechnology approved in the Philippines. Corn is one of the most important crops in the Philippines, second to rice, because it is a staple food in the Visayas region and across the Philippines it is used as feed for our chickens and other animals. If you look at our poultry farms and our pig farms, you will see lots of corn, because they depend on it for their survival.

One of the major pests in our country is the Asiatic corn borer, which damages 30–70 percent of our corn. I had one experience during the period when BT Corn had not yet been approved. Due to the Asiatic corn borer I barely had a return on my investment.

In the first planting, I had extensive damage done by the corn borer infestation. After seeing the damage, I saw little point in planting corn. The corn borer is active year round, and I had to spray my crops six times within one crop season. In the Philippines we are even using systemic granule pesticides on the corn. One of my farmers was hospitalized because he was poisoned from the toxic chemicals. So this is the damage done by the corn borer.

In my first experience in planting BT Corn, I was really amazed. And you can see in pictures of my farm, the corn is very "clean." Since I was a small boy, my father planted corn. And I would see our corn often damaged from the corn borer. But now I see that it is very healthy. When I hired people to weed my cornfields, I told them, 'If you can find a single corn borer, I will give you one thousand pesos.' And one thousand pesos is

a lot of money in the Philippines. I was nervous, because if they found a corn borer in my field, then I had to pay them. But at the end of the afternoon, when I asked them, no one had found any damage from the corn borer in my corn.

During the harvest time, we could see that the corn was really clean and really wonderful. The first corn, which we had planted in June – after it was approved in 2002 – was the 818 Yield Guard, which is very effective against the corn borer. We saw a great many spiders, whereas before we did not see spiders in our fields because they were killed by insecticides.

During the harvest time my corn was very clean, in comparison with my neighbor who had planted a non-biotech corn, and you could visibly see the damage done by the corn borer. My neighbor had harvested only 2.3 tons, but I harvested 7.2 tons. The year before with my conventional corn, I had only harvested 3.5 tons a hectare. It doubled my production and I earned a net income of 41,000 pesos per hectare, an income increase from my usual 13,000. That was of great help to my family.

At this time the media in the Philippines was saying that GM foods would cause cancer if you ate them, and that they would cause other diseases in the future. There was even a warning that if you walked through a cornfield while it was flowering, it would affect your sexuality. All these scare tactics and arguments were unfounded.

In fact we eat my BT corn, even though it is intended for feed. I had told those who were against the technology, 'If this is approved for commercial planting, I myself will be the first to eat it, just to prove to you that it is safe for human consumption.'

The BT Corn has helped us. It increased our yield and doubled my own production. I was able to buy a refrigerator and with the second crop, I bought a motorcycle. I have seen the benefits of biotech corn.

During the first planting season, there were only three of us who planted biotech corn, because some of the farmers were afraid to due to the scare tactics of anti-biotech opponents who were saying it is not good and that it can make you sick. Farmers were afraid. After the harvest, I told the company, "We should have a harvest festival." And we invited all our farmers, our neighbors, and even from far away, we invited them to that forum. And I told them that this corn is good. And the farmers saw that the corn was really wonderful, with no damage form the corn borer. In 2002, the Department of Agriculture approval of BT corn for commercial planting made our farmers very happy. In one hectare of land we had harvested 7.2 tons of clean and dry corn, up from 3.5 tons. We did it with less pesticide spraying, thereby protecting the health of the farmers and the environment. We only sprayed once. In my experience, I did not use insecticide in the first planting, because I wanted to see whether it was really true that this was effective against the corn borer.

And the policy statement on biotechnology of President Gloria Arroyo Macagapal is positive about these advances. She said, 'We should promote the safe and responsible use of modern biotechnology and its products as one of the several means to achieve and sustain food security, equitable health services, sustainable and safe environment and industry development.'

In General Santos City, there was a councilor who sponsored a moratorium on BT Corn, ensuring that it would not be planted in the city for five years. Three years after the moratorium started, I went to the councilor's farm and saw he had planted BT Corn. I asked him, 'Councilor, why did you plant BT Corn? Your resolution is still standing, there are still two years remaining.' And he answered me, 'I have seen the

benefits of the BT Corn, before I did not have enough information. I made a mistake with that resolution. But now I am planting BT Corn.'

Even my child tells me, 'Papa, you are not mistaken. Biotech is good for my future.'

My child will tell the scientists, 'I am happy now, because I have a future, thanks to the dream corn that you have produced.' It will feed the hungry. It will feed the world. And this is only one of the means in which modern biotechnology can help us.

Thank you.

How Developing-World Farmers Have Used Biotech Crops: The Impact of Bt Maize: A Farmer's Experience

Ms Sabina Khoza

Secretary General, National African Farmers Union
Gauteng, South Africa

I would like to give some history of South Africa, so that you can understand where I come from. I am a proud indigenous woman working in agriculture. That is why I am standing here before you. And thank you again very much to the people who made it possible: the organizers and everybody else. I bring greetings from ninety-seven percent of the six hundred and eighty thousand women who are farming in South Africa, who have small-scale farms, are mostly illiterate, who have kids to take to school and who depend on this technology. They are watching, believe me. And I'm here today because of this technology.

Today, I want to talk about being the director of a field-training center. I never thought that one day I would be counted amongst the directors, and have a training center of my own. It's due to funding from the National Department of Agriculture in South Africa. The Minister of Agriculture, a woman, and a rural woman as well, came to support the National African Farmers Union – one of the two unions in South Africa, black-dominated, with no real commercial farmers. The white-commercial farmer dominated Farmers Union had previously enjoyed most of the benefits of technology. So how do you get university education to indigenous women farmers? After our meeting with the Minister of Agriculture, she made a recommendation, and approved a budget, and a thousand South African women went to Van Dye, the nearest university, for two weeks. On the sixth day I visited them. All that they told me was how delicious the food was, how comfortable they were sleeping. But above all they felt very inferior. They felt they could not make it as farmers; that they would not be successful because they could not understand the equipment, much less have the ability to purchase it.

I went back to the Minister and said, "Minister, I think I have a social responsibility to assist these women. I have the land. But we should do things the traditional way, the way they know it, and overcome these feelings of inferiority." That is how we started, and so far we have trained two hundred and fourteen entrepreneurial South African farmers who now have businesses of their own, and belong to a program called Land Redistribution for Agriculture Development (LRAD.) And it is doing very, very well. Little did I know that by encouraging education, I would have the opportunity to create employment. But let us talk about biotechnology. When I first heard of biotechnology, I was currently serving in district government as the agricultural coordinator. There was a big advertisement in Soweto, the largest township in South Africa, that shows a picture of a genetically modified tomato with the head and tail of a fish. Because I am in the

agricultural sector, I wanted to know what GMOs were. I wanted to know what this monster was, and how we could avoid it. I had a training session with AfricaBio, where they said, "With this maize that you plant, you are going to use less pesticides, no corn borers." I said, "No way. I've never seen that. My family has always planted this way and we are used to corn borers. We know it as tradition. So you are telling us something else. And if this is technology, let us do it." We started with the help of the South African Government, Agriculture Research Council, which has technicians, and they helped us plant half a hectare. As the maize was growing, we had a lot of work to do on the 9-DT. We had to do the spraying, and all those things, using lots of time on the 9-DT. On the BT maize side, it was so beautiful. The fifteen people who were working on the project, they spent less time, had less work to do. They even asked for seedlings. They started planting their own vegetable gardens. To me this was really something very good. And today their vegetables are now in some of the stores of South Africa, just because of the improved seeds. The farmers using BT corn have increased their income. I think seventy-five percent of our money was budgeted for pesticides, instead we bought seeds and seedlings with that money, and we improved our business.

There it is, the BT maize, my initiative. Because of BT maize, I again became an employer of twenty-five staff who were not previously employed. That first hectare, worked so well, that we started growing more in South Africa. We started harvesting our millet when it was still green. We eat it as green millet, we roast it as green millet. So we started even getting income before the grain was even dry. And again, I would like to thank our Ministry of Agriculture, the Agricultural Research Council, and Van Dye University for making sure the farmers were not taken for a ride. Not only are we growers, we are farmers, and we are the very first consumers. Don't forget that whatever we are planting, we have eaten it, have consumed it, before it even goes out to the market, and here I am – healthy.

This is now going to be my third year planting BT maize. The first and the second year we did our fields 50–50, now we are doing 75% BT and 25% non-BT. The reason we continue with some non-BT corn is that we need other farmers to have choices, like we did. Nobody ever forced BT down our throats. It was because of our field-trial case studies that we have chosen now to go 75 / 25 %. Those are the results and I am very proud of our results. Now even if one is not well educated, visually one can see the difference between BT and non-BT maize. And again, it is by choice that we in South Africa are planting genetically modified maize. And it is my choice. I am not a scientist, I'm a farmer, but you can actually see the difference. And it frustrates you as you go into your field and find your field with a poor yield, when you expected a big harvest. Should we go back, or choose the technology way? I'll definitely choose the technology. I've didn't walk to Italy by the way. I flew, because of technology. If I had to walk, I would still be on my way.

Biotechnology has many benefits to me as a small farmer. I see it as very safe. It really reduces the use of chemicals. You know, when you spray these chemicals, you find that about 35% cover you when you thought they were going on the plants. You end up in the hospital. You end up not being able to take care of your children. You end up going to the doctor that you can't afford. What can biotechnology offer to the small-scale farmer? I believe you develop faster, safer, more nutritional agricultural products. Our products are now in Shop-Rite Checkers, a major retail shop in South Africa. For us to have our product there, that means we have very, very high standards. Controlling pests

and diseases that can wipe out entire crops is one of the biggest benefits biotechnology offers. The old way of farming left us vulnerable to diseases that would wipe out your crops. There is, of course, a cost. The cost of BT seeds is very high. As a little girl, my granny would say to us that you should keep the best seeds for the following year and sell some of the excess seeds. But we were not sure that each and every seed that we were planting would germinate. So as a farmer, if I need good quality, then I need to pay for it.

There are internal trade problems in South Africa. Farmers say to me, 'What if we plant BT maize, and want to sell it abroad, but they won't buy it?' I understand those concerns, but the question that should be asked is: Why in South Africa, as a small-scale farmer, are you thinking of international trade, when you cannot even meet your local needs?

Progress has definitely been made. There are two trial fields in Gauteng province, South Africa: one belongs to a government-owned entity; the other belongs to us, the LRAD farmers and we compare yields. And a lot of South African farmers come there for this information. We offer 70% practical experience and 30% theory. But now the farmers know it – they dig it, they plant it, they grow it and they harvest it. The sector that is benefiting the most is the farmers.

Feeding a Hungry World: The Moral Imperative of Biotechnology

Lester M. Crawford D.V.M., Ph.D.

Acting Commissioner for Food and Drugs

Good afternoon, I'd like to thank Ambassador Nicholson for his kind introduction and for his invitation to speak to you this afternoon about U.S. regulatory policies for biotech foods, or as we refer to them in the United States, genetically engineered foods.

It is indeed both an honor and a privilege to be here today and share with you the many ways that the United States government assures the safety of genetically engineered foods so that scientific advances in food production may benefit not only the American people, but people throughout the world.

I would like to commend the forward thinking and support of the Holy See in recognizing and publicly acknowledging the potential for the technology of genetically engineered foods to be part of the framework of the Vatican's efforts to promote human dignity by eradicating poverty, hunger, and malnutrition and promoting economic well-being. The U.S. especially applauds the support of the Holy See for a science-based approach to this issue.

Already today at this conference you have heard how the scientific advances in genetically engineered crops offer new promise not only for feeding the millions of hungry people around the world, but also for improving the nutrition and health of all people. You have also heard how biotech food crops can aid developing countries in reaching food sufficiency and enhancing their economic development, and how small farmers in Africa and the Philippines are already using genetically engineered food crops to their advantage.

It is my pleasure to share with you today the extensive system of safeguards that the U.S. government has in place to assure the safety of genetically engineered foods not only for the American people, but also for people around the world who import U.S. food crops and manufactured foods, and for those who receive U. S. food crops as food aid through the United Nations World Food Program.

Background

The United States has more experience in the regulation of genetically engineered foods than any other country in the world. In 1986, under the guidance of the White House Office of Science and Technology Policy, the United States developed a coordinated framework for the regulation of genetically engineered products. The decision was made that genetically engineered products (foods and drugs) would be regulated under existing legal authorities, and that safety assessments would be based on product characteristics. In other words, the U.S. regulates the product and not the process by which the product was developed. The U.S. Government agencies directly involved in these regulatory policies include the Department of Health and Human Services' Food

and Drug Administration (FDA) and National Institutes of Health (NIH), the Department of Agriculture (USDA) and the Environmental Protection Agency (EPA).

The distribution of responsibilities among these agencies is clear. The USDA oversees the safety for the cultivation of genetically engineered crops and addresses plant protection issues. The EPA is responsible for overseeing the safe use of pesticides, including [pesticide] substances produced in genetically engineered plants. EPA also sets tolerances or establishes exemption of tolerance for these [pesticide] compounds in foods and in the environment. The NIH, as the premier research agency in the U.S. Government establishes the guidelines for recombinant DNA research. The FDA, the agency I represent, has the major responsibility for assuring the safety and proper labeling of foods, feed, and pharmaceutical substances derived from genetically engineered plants. The agency's statutory authority for these activities are codified in the Federal Food Drug and Cosmetic Act which gives FDA oversight of all cereals, fruits, vegetables, plant by-products, milk, seafood, and all substances added to foods. FDA also is responsible for post-market monitoring of foods for adulteration, for pre-marketing approval of food additives, and for assuring appropriate labeling of food products.

In 1990, the first food additive produced through genetic engineering, a form of chymosin, a milk-clotting enzyme used for cheese production, was affirmed as being virtually identical to its natural counterpart and granted GRAS status (generally recognized as safe). The first genetically engineered whole food crop was introduced into commercial production in the U.S. in 1994. By 2001, more than 109 million acres worldwide were planted with bioengineered crops and this acreage has continued to grow.

The United States accounts for about two-thirds of all the bioengineered crops planted globally. The social and economic benefits derived from the use of genetically engineered food crops has been widely recognized by U.S. farmers, to the extent that, as of 2002, at least 68 percent of the soybean crop planted in the U.S. consisted of genetically engineered varieties along with approximately 26 percent of the corn crop, over 70 percent of the cotton crop, and about 55 percent of the canola crop.

Most of these genetically engineered crop varieties consist of herbicide or insect resistant varieties. These types of crop varieties could be invaluable to developing countries in helping them toward food sufficiency. Opportunities abound for the development of genetically engineered crop varieties with enhanced nutritional content such as the increased vitamin A content of golden rice that can improve the health and nutritional status of those most in need.

U. S. Government Policy for Genetically Engineered Foods

The FDA established its basic policy on genetically engineered foods in 1992. This is the policy, along with subsequent clarifications that is in effect today. This "Policy on Foods Derived from New Plant Varieties" was published to provide guidance to developers and producers of new plant varieties, and applies to **all** methods of plant breeding, including techniques using recombinant DNA.

The basic principles in this policy statement are: 1) that the regulation of new plant varieties should be based on the objective characteristics or components of the food, rather than the method used to develop the food; 2) new foods must be as safe as foods already on the market; and, 3) new plant varieties are evaluated relative to traditional counterparts.

New substances introduced into food via plant breeding (either traditional or bioengineered) are considered food additives if they are not GRAS or pesticides.

In 1995, we provided additional guidance on a voluntary consultation process whereby producers of genetically engineered foods voluntarily notify the agency before marketing a bioengineered crop seed or food. This prior notification is to ensure that new food products are safe and lawful. Genetically engineered crops are evaluated on a case-by-case basis, there is no "required' battery of tests. The level of consultation needed is dependent on the novelty of the genetically engineered product.

Notification leads to a two-part consultative process that involves a discussion of relevant safety, nutritional, and other regulatory issues and a subsequent submission by the developer of a safety assessment report. The safety assessment involves a multi-disciplinary approach that includes the agronomic and quality characteristics of the plant, the characteristics of new substances that are introduced into the plant through genetic engineering, a genetic analysis, and a chemical and nutritional analysis.

Safety Evaluation

All foods, whether conventional or bioengineered, pose the same types of inherent risks to human health: the potential to contain toxins, allergens, and anti-nutrients. Safety assessments for bioengineered foods thus should focus on whether the genetic change alters the potential toxicity, allergenicity or level of anti-nutrients compared to the conventional food source. In addition, the FDA encourages an evaluation of the safety of intended changes to nutrient composition and compositional analysis for unintended changes.

Specific elements of the safety evaluation include: 1) analysis of the intended modification or new substance relative to its identity, source, digestibility, dietary exposure and nutrition characteristics; 2) analysis of unintended modifications as to the genetic stability over multiple generations, analysis of nutrient, anti-nutrient and toxicant levels; 3) characteristics of the host plant, including its taxonomy, history of safe use, normal presence of harmful constituents and important nutrients; 4) characteristics of the donor organism including its taxonomy, history of use, presence of harmful constituents, passage through microbial hosts, and the identity and function of the introduced material; 5) analysis of the substance introduced into the host plant including the concentration of the expression product, its potential for allergenicity and for toxicity, its similarity to other substances in the food supply, and whether it causes alterations in plant metabolism; and 6) evaluation of the inserted genetic material in terms of the methods of transformation used, the activity of the regulatory sequences of the gene the number of inserts and insertion sites, and its genetic stability.

[The] FDA also developed additional guidance for the food industry regarding safety assessments for the use of antibiotic resistance marker genes in bioengineered plants. This guidance indicated that when such genes are used, the safety assessment should also determine whether the presence in food of the enzyme or protein encoded by the antibiotic resistance marker gene would compromise the therapeutic efficiency of orally administered antibiotics through transfer of the gene from plants to microorganisms in the gut of man or animal, or in the environment.

More recently we issued draft guidance for industry on voluntary labeling to indicate whether foods have or have not been developed using bioengineering. This document

lays out four guiding principles on appropriate ways the industry could voluntarily provide information on a food label about bioengineering.

To date, bioengineered foods have proven to be no different from their conventional counterparts and so, although the FDA issued a proposed rule in 2001 concerning making the voluntary notification of intent to market mandatory, this rule has not yet been finalized and the voluntary notification procedures remain in effect.

I'm pleased to report that to date all developers of bioengineered foods have voluntarily consulted with the FDA prior to marketing their products, and the FDA maintains a listing of these completed consultations on our website. I am also pleased to tell you that the procedures that the U.S. Government has had in place for assuring the safety of genetically engineered foods since 1992 are fully compatible with the *Principles and Guidelines on Foods Derived from Biotechnology* adopted by the Codex Alimentarius in July of 2003.

While it is true that the FDA evaluates genetically engineered foods for the U.S. population, the U.S. has a very ethnically and racially diverse population that also includes large numbers of sick and elderly. Thus, assurance of safety for the extremely diverse U.S. population should reflect its safety for non-U.S. populations. The FDA would not allow a food to be marketed if it believed that the food would cause harm for some segment of the population, unless the food could be clearly labeled to alert specific subpopulations (e.g. those with allergic reactions).

The characteristics of genetically engineered varieties of food crops, available to date, have focused primarily on insertion of genes that confer herbicide or pest resistance or both to the plant, or alter ripening characteristics or oilseed composition. There is no scientific evidence to indicate that there would be a greater risk to consumers or the environment if these crops were grown in developing countries rather than in the United States.

Ongoing Initiatives

To ensure that U.S. policies and procedures on genetically engineered foods stay current with the latest scientific and technological advances, the FDA has a group of outside experts who serve on the Food Biotechnology Subcommittee of the Food Advisory Committee, and provide advice on science-based approaches to assessing potential risks.

In addition, the FDA in conjunction with USDA and EPA commissioned the U.S. National Academy of Sciences and the Institute of Medicine to develop a science-based framework to assess or predict unintended health effects of genetically engineered foods to assist us in our evaluation of these products prior to commercialization. This report was released at the end of July of this year and outlined a decision tree for the safety assessment of genetically engineered foods that tracks closely with the FDA's current procedures. The report also confirms the FDA's belief that the genetically engineered foods evaluated by the agency and marketed to date, do not pose unexpected health concerns for consumers.

We are currently nearing completion of a draft guidance concerning field trials of bioengineered food crops. The development of this guidance is a high priority for the Administration and the industry, to enhance public confidence, avoid product recalls, and provide an international model to address the presence of low levels of bioengineered plant material in non-bioengineered crop fields.

The goal of this guidance is to ensure that material from field trials is safe prior to any inadvertent entry into the food supply. In essence, this would be the protein safety component of a full voluntary consultation relative to the protein's toxicity or allergenicity. It would not replace the full consult prior to marketing.

Pharmaceutical Crops

With continued and rapid advances in biotechnology come many new and interesting challenges for the FDA. The production of food crops engineered to produce pharmaceutical and industrial compounds is one of these challenges. While the FDA has sole responsibility for ensuring the safety and efficacy of the pharmaceutical products produced by plants for use in humans, we share the responsibility for ensuring the safety of these products developed for use in animals with USDA. Currently, the FDA is considering an adventitious presence guidance document analogous to that for food-use crops.

However, if a genetically engineered plant whose new characteristics have not been affirmed as GRAS or received previous approval as a food additive should inadvertently get in to the food supply, the FDA has procedures in place under existing legal authorities to remove the contaminated foods from the market.

This was well demonstrated in the U.S. Government's response in 2000 to the appearance of StarLink corn in the food supply, StarLink contains a pesticidal protein that makes corn resistant to certain types of insects, and had not been approved for human consumption. At the FDA's urging, corn dry-milling operations began a testing program to screen all yellow corn intended for human food use. This testing program remains in effect today, even though the frequency with which the StarLink gene is being detected has declined significantly. Should the U.S. government develop a revised testing protocol leading to an exit strategy for domestic testing as the presence of contaminated product declines, this will not preclude continued testing of food-aid corn.

U.S. Government Assistance in Capacity Building

Because of our extensive experience in evaluating the safety of genetically engineered foods, the FDA and other relevant agencies of the U.S. Government participate extensively in capacity building programs to assist other nations in developing appropriate regulatory frameworks. For example, the FDA has conducted joint training sessions with our colleagues in Canada, Australia, and other countries for representatives of other governments to teach them about food safety assessments of genetically engineered foods. Workshops have been conducted in Moscow for the Russian Federation and neighboring countries, in Mexico, and just in the past few weeks we conducted a workshop in Jakarta for ten Southeast Asian countries.

In addition, the FDA provides scientific technical assistance in conjunction with the U.S. Agency for International Development (USAID), the Dept. of State and the USDA Foreign Agriculture Service in meetings with health officials from other countries. In October of this year, the U.S. Government is sponsoring a meeting in New Delhi on U.S. – India regulatory issues.

The FDA also routinely meets and shares U.S. Biotechnology regulatory processes with foreign regulatory officials who come to the U.S.

Conclusion

In closing, let me just say that the FDA, as the federal agency charged with safeguarding the public health of the U.S. population, is grateful to the Pontifical Academy of Sciences and the Vatican for the foresight in recognizing and advocating for the tremendous potential of genetically engineered food crops to enhance the ability to feed the hungry of the world, to contribute to improved nutrition and health of the world population, and to enhance food production capabilities in developing countries.

Your efforts to convey the facts about genetically engineered foods to needy countries constitute a real service to humanity. We must continue to work with the UN World Food Program and other International agencies to help equalize the chances for the people of all nations to have safe and adequate supplies of food in order to live healthy and productive lives.

Debunking the Myths on Biotech Food and the Developing World

Dr. Piero Morandini, Department of Biology

University of Milan

I will try to give a catholic (and possibly a Catholic) perspective on the issue, that is, to mention all of the common misconceptions, but will go into the details of just one or two at the most in each category because of time limitations.

- **Biological misconceptions:**

1. Reducing the environmental impact of agriculture improves biodiversity (extensive agriculture is less damaging than intensive agriculture).
2. Agricultural biotech is inherently different and more hazardous than plant breeding.
3. Transgenic plants are not natural (scientist 'playing God')

Main argument:

The crucial issue is the definition of what is 'natural' (and of course how we define 'nature'); I assume we can accept, for the present discussion, the definition that natural is 'what happens without the intervention of man'. We need then to look at the way natural selection and human selection work. Examining just some characters (dehiscence of mature fruit/ear, dwarfness, seed dormancy, regeneration capacity, natural pesticides content, weeds), we can easily realize that domestication has imposed an incredible burden of unfavorable alleles onto cultivated species, thereby changing deeply their biology. If crop plants were to grow like weeds, we wouldn't need agriculture!

Cultivated plants are unable to survive without the constant intervention and support from man, therefore they cannot be considered as natural. Moreover, genetic modification has a long history: first intra-specific crosses, then inter-specific crosses, then much broader crosses using embryo rescue techniques, then chromosome (genome) doubling techniques, then somaclonal variation, then mutation breeding. Finally, Agrobacterium, a natural genetic engineer, and restriction enzymes and ligases, are "nature's gene-splicers".

In this sense, we are clearly doing nothing that is not already done in nature, as God has shown us the way in which we may engage in more sophisticated genetic modification.

We are just doing it consciously! Does this turn a natural thing into a non-natural one? [1]

If nothing exists beyond nature, why is man a non-natural being?

If man has no special place in the universe, why should he take care of beings

1 "Any amount of theology can now be smuggled into peoples mind under cover of romance without their knowing it". (*Letters of C.S. Lewis*, W.H. Lewis, ed.)

other than humans? (i.e. why on earth should humans have a non-anthropocentric worldview?)

4. Transgenic varieties will overrun all existing traditional varieties and wild species damaging biodiversity (genetic contamination as a disaster).

Main argument:

Biologically speaking gene flow among cultivars or between wild and cultivated species has happened in the past and will continue to do so in the future regardless of our perception or whether transgenic crops are involved. Question is: are there characteristics in transgenic crops making them so effective to grow that they will eventually outcompete all other plants/varieties ('weed' effect)? Is their character particularly dangerous when transferred to other cultivars or species, which might irreversibly contaminate the environment ('Pandora' effect)?

The biological differences mentioned above have deep consequences on the survival rate of cultivated crops in the wild. Since transgenic plants are cultivated plants with just one or two additional genes, then they are not going to behave differently from conventional varieties unless these additional genes confer an enormous increase in fitness able to overcome the burden of unfavorable alleles. The same is true when considering gene flow to wild species, which is not a major problem for natural ecosystems. It might pose *some* risks for *certain crops*, with *some characteristics* (e.g. herbicide tolerance) *in some 'agricultural' ecosystems*. In other words, it has to be examined on a case by case basis and it might be a concern only in few cases.

Major comment

Scientific evidence does not support, so far, the notion that natural things are inherently superior to man made ones. The myths mentioned above stem from a pagan worldview: nature as a goddess and environmentalism as a form of religion (nature knows better than humans) in which man is the worst enemy of nature and at the same time it is called to repair and defend it.

In a Catholic perspective, rather than natural (i.e. spontaneous) and non-natural, we should speak about conscious and unconscious acts, but conscious does not mean good ("video bona proboque, deteriora autem sequor"). Therefore we start implying ethics and moral values.

- **Post-biological misconceptions:**

5. The scientific community is divided over the safety of GMOs for the environment and human health (i.e. the issue is controversial with some in favor and some against).
6. Regulation is insufficient or non-existent. More regulation needed.
7. Modern agriculture doesn't need biotech because:
   A) People in rich countries can afford DOC & organics; no need to increase or improve production.
   B) Poor people have they own plant varieties and these are good for them.

Main argument:

A) Are we really satisfied with our agricultural system? Let us take Italy: we import each year more than 5 million tons of maize, soybean and derived product to feed our farm animals[2] (not to mention the million tons of imported meat fed with transgenic crops...). Our home crop production is unable even to meet the requirements for DOP-DOC productions implying that we do use maize and soybean imported also from countries growing GM crops (e.g. Argentina or Brazil) even for making these 'quality' products.

It is therefore immoral to claim we are a GMO free country and that we do not need to grow them while we depend so heavily on importations – and therefore are already using them.

B) While it is true that every country has its own landraces and that preserving this biodiversity is an important issue, we have to recognize that at present many countries (particularly in Africa) suffer from hunger and malnutrition. Pests and post-harvest losses[3] leading to hunger are still a problem in many places and cannot be solved systematically through alms (not a desirable situation being unable to feed your children and being forced to beg). Food safety is an issue[4] (e.g. mycotoxin contamination). There is need for technological developments where landraces and conventional technologies have failed. Genetic engineering is one of the tools and a most promising one because it is a technology 'in the seed'. It can help address many of the problems in developing countries by providing virus-resistant, insect resistant or nutritionally enhanced varieties, just to mention a few, and it has already shown its usefulness (e.g. Bt crops). Of course poor nations do not need technological imperialism (i.e. only products), therefore it is important in the long range to provide them with the means to pursue their own solutions.

8. Ag-biotech is an expensive technology and therefore only multinational corporations (MNCs) have access to and control it.
9. MNCs selling transgenic seeds have patented everything and control our food supply.
10. Farmers buying GM seeds are only gullible customers not knowing their interests (remarkably frequent, especially in developing countries, given that 6 out of 7 million of such customers are resource poor farmers!) ("contadino: scarpe grosse e cervello fino" that is: farmers have big feet but fine brains)
11. Transgenic seeds will create new forms of slavery among poor farmers in developing countries (by the way, are maize growers in developed countries all slave of MNCs? they have to buy seeds every year).
12. The problem of hunger in the world can be solved by redistributing production because the actual production is enough to feed all the world's people. The real problem is therefore redistribution – not production (half a truth which becomes eventually a lie).

---

2 see the FAO statistic server on: http://faostat.fao.org/faostat/collections?subset=agriculture (select the 'Agriculture and food trade' section and recover data by country, item and year)

3 "The biggest risk in Africa is doing nothing. I appreciate ethical concerns, but anything that doesn't help feed our children is unethical." (Florence Wambugu)

4 Gressel et al., (2004) Major heretofore intractable biotic constraints to African food security that may be amenable to novel biotechnological solutions. Crop Protection 23 (2004) 661–689.

Comment

Post-biological myths usually stem from a mixture of the pagan worldview mentioned above with remnants of a broad anti-capitalism: that nature not only knows better, but man is greedy, making things worse. In other cases nostalgia for an idealized past – when, they believe, taste was superior and food healthier – plays a role, particularly for affluent people. Trade wars among countries or farmers associations are also at work.

While evil is a possibility for all human beings (we do not need much exemplifications these days, do we?) it does not necessarily correlate with the size of the company for which they work. Small farmers can be equally greedy because evil comes out of man's heart (see Mt 15:18–19; "But what comes out of the mouth proceeds from the heart, and this defiles a man. For out of the heart come evil thoughts, murder, adultery, fornication, theft, false witness, slander.")

For those who see or seek only an opportunity of increasing their income without limit (be they MNCs or anybody else), Scripture reminds us through prophet Amos that a hard judgment rests upon those who exploit the poor (see Am 8: 4–7 "Hear this, you who trample upon the needy... deal deceitfully with false balances... and sell the refuse of wheat").

The words of Matthew's Gospel on the last judgment (Mt 25:31–46) provide the 'comparison stone' for the ethics of agricultural biotechnology – to feed the poor, clothe the poor, and liberate the poor from the prison of poverty. If it fulfills these requests, then Ag-biotechnology is a moral imperative.

Additional remarks

As a scientist I might understand little of economics and be even less interested in it, but know that people distorting or reporting science inaccurately have less credibility also on other issues.

And while I can understand the view of the agro-nostalgic[5] and share some of their desire, I also share the desire "that we may lead a quiet and peaceable life, godly and respectful in every way" (see 1Tm 2:1–4). But how can we live such a life if many of our fellowmen do not have enough to eat and suffer from curable diseases? Is it ethical to withhold a technology that helps poor people? Surely anybody would agree it is not, and critics of ag-biotechnology would make the point that this technology does not help the poor but rather makes things worse. So it is crucial to ascertain whether the technology has been useful or not. If the experience shows that poor farmers do benefit from ag-biotechnology (and as far as I know they do), then I do not mind whether companies make money or how much. And even if the technology had not provided so far any benefit to poor people, then I would still believe that it could in the future.

Science will not automatically solve the problems connected with under-nourishment and hunger. Many changes are still required in the social structure and education system of poor nations, as well as in heart of those peoples living in areas of perennial conflict.

---

5 "their aim is, as far as possible, to use nothing which is the product of the factory system or of modern industry in general; for they think these things so iniquitous that every one is more or less party to a crime in using them..." (*C.S. Lewis: Collected letters*, W. Hooper, ed.)

Similarly, science will not solve the problems of meaning nor extinguish the longing of the human heart for its fulfillment ("Inquietum est cor nostrum donec requiescat in Te, Domine" St. Augustine's Confessions), but can help to reduce (or increase, depending on man's will) human suffering. Eliminating science does not eliminate ethics!

Scientists are often considered like prostitutes- no one admits frequenting them, but many people do go to them and exploit them! It is common to blame science for many evils, but you barely find people who live without using and abusing the products of science and technology.

We can reduce our consumption, but poor people will only benefit if we save first the money and use it for providing food in the short term and, in the long term, education and technological capacity.

There is a lot of confusion also inside the church on this issue, confusion born out of ignorance and fuelled by ideology (see Mt 26:8–9 "Why this waste? For this ointment might have been sold for a large sum, and given to the poor"), but tearing our own clothes is not going to feed the poor. If the critics of biotechnology want to help poor people (and I believe part of them do), then I suggest that everybody focuses on positive actions: do what you believe helps feeding the poor, not just oppose what others do. And if some approach of yours turns out to be more effective than the approach pursued by ag-biotechnology, we will rejoice for it.

Last but not least, if we really want to further exploit the potential of biotechnology to the benefit of the developing world and do it as soon as possible, every player has a role.

Regulators: to not put an extra burden on science.
Patent holders: to easily allow for humanitarian clauses.
Scientists: to tackle problems academically less appealing.
Decision makers[6]: to set up funding and base their decision on sound science, not on polls.
MNCs: to provide knowledge and funding (a most effective media campaign...).
Consumers: to accept minute risks connected to the technology.

The Pontifical Academy of Science could suggest which agricultural traits might be most useful to poor farmers (e.g. note [7]). Is there a company or a group of companies willing to pursue the project and give the crop for free to poor farmers to resource?

Acknowledgements

The support of the scientific committee for Ag-biotech of the Lombardy region.
Colleagues and friends (many indeed) for suggestions, material and criticism.

Disclaimer

Any view expressed in this document must be considered solely as personal.

6 "The most improper job of any man, even saints, (who at any rate were at least unwilling to take it on), is bossing other men. Not one in a million is fit for it, and least of all those who seek the opportunity." (*The letters of J.R. Tolkien*, E. Carpenter, ed.).

7 Example of a trait which could be very relevant to poor countries: http://www.mendelbio.com/products/index.htm

NOTES

NOTES

NOTES