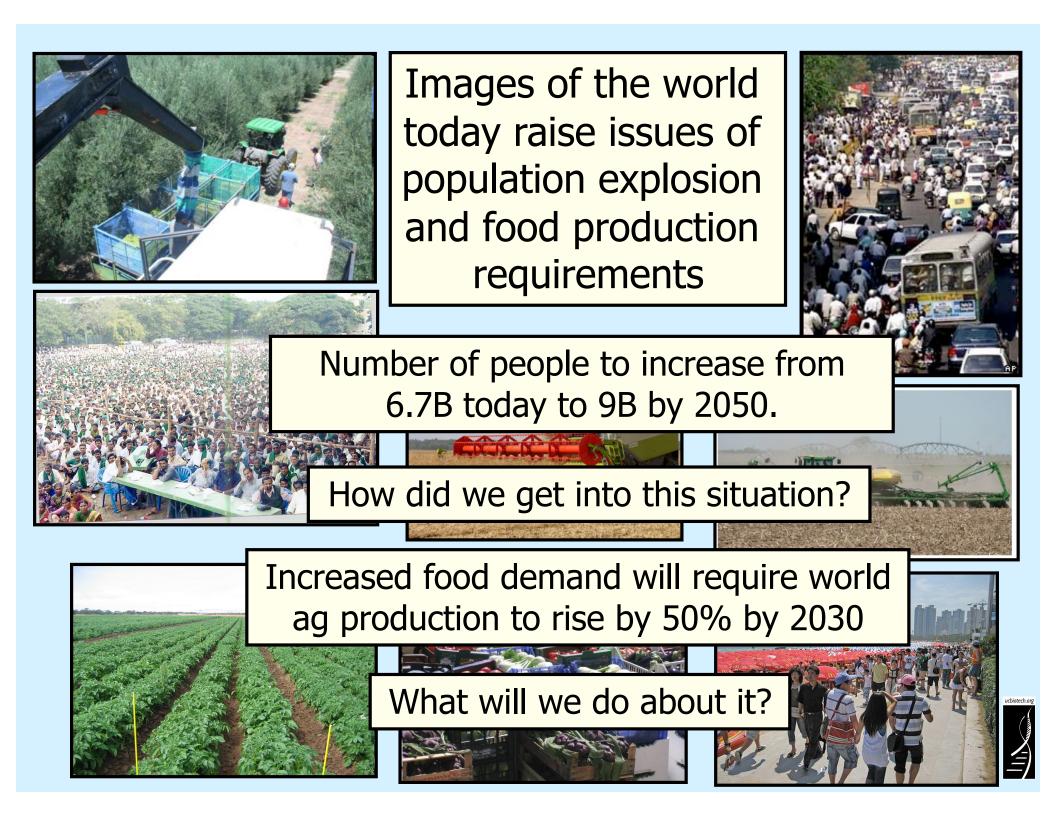


FEAST, FAMINE and the FUTURE of FOOD

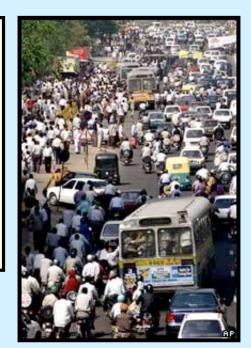
Peggy G. Lemaux
University of California, Berkeley
http:/ucbiotech.org
http://pmb.berkeley.edu/~lemaux





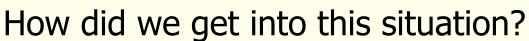


Images of our world today bring up issues of population explosion and food production required.









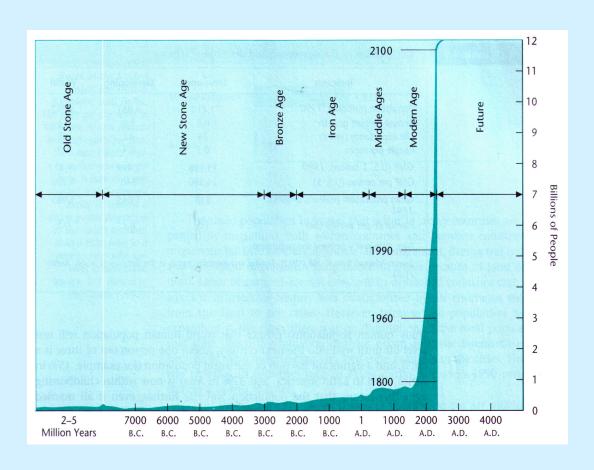








2,000 years ago – 300 million people worldwide – approximately same as in the U.S. today!



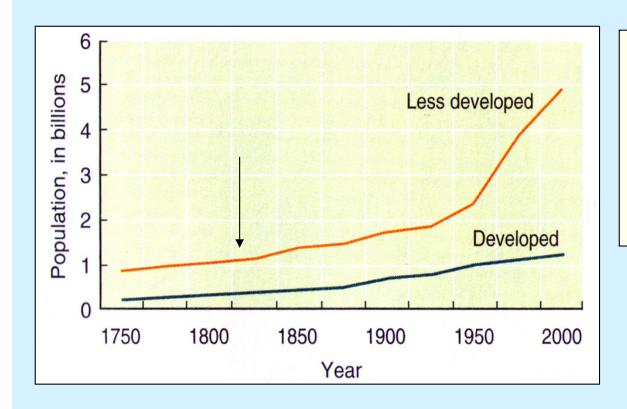
2000 years ago: 500 people added to world each day.

Today: 200,000!



Long ago hunter/gatherer lifestyles led to moderately high birth and death rates.

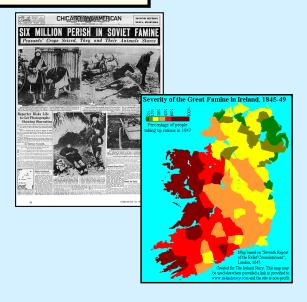
~10,000 years ago, agriculture began replacing hunting/ gathering.



Up to 1800, reliable food supplies and a settled existence led to dramatic birth rate increases but...



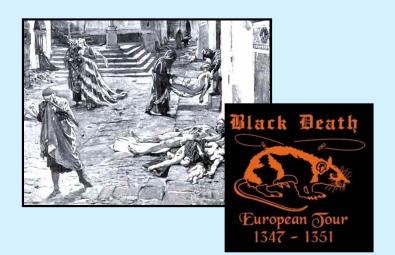
FAMINE,





and

DISEASE



kept populations down

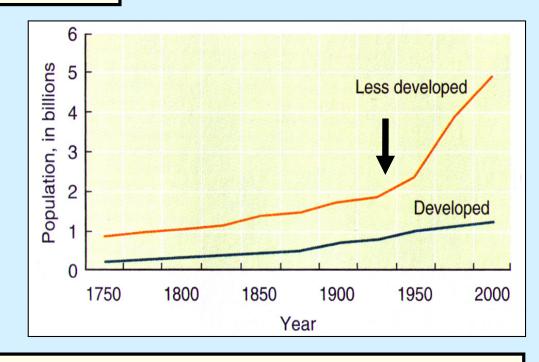


Dramatic population explosion in last 80 years.

Why?

<u>Rising income</u> = more people could buy food

Improved housing/ public hygiene = decrease in infectious disease





Food production more dependable due to improved transportation

<u>Medical advances</u> led to disease agent identification / treatments to control diseases



Europe and North America: industrialization over hundreds of years

In Asia, Africa, Latin America, improvements were "overnight" (last 50 years) with populations growing extremely rapidly





Comparison of developed and less developed regions

Indicator	Developed	Less Developed	World
Population (millions), 2002	1.193	4,944	6,137
Annual percent growth	0.1	1.6) 1.3
Life expectancy, years	/5	64	67
People per room	0.7	2.4	1.9
Mortality under 5, per 100 births	0.8	, 6.1	5.6
GNP per person, US\$	20,520	3,300	6,650
Grain production, millions of tons	810	1,259	2,069
Farmland/person, hectares	1.5	0.6	0.7

Led to 16-fold increase in % growth in less developed countries...



But grain production did not keep up - only 1.5-fold increase!



No increase in grain production due in part to mass exodus from rural areas (and farming)...





to urban areas, resulting from industrialization - putting increased pressure on agricultural systems.



And types of foods eaten has also affected agricultural production

Comparison of the diets in India and United States

Food	Source of calories		Source of protein	
	India	United States	India	United States
Cereals, starchy foods	65%	25%	64%	21%
Sugars	6	12		
Beans, lentils	10	4	18	3
Fruits, vegetables	2	6	1	4
Fats, oils	4	19		
Milk, milk products	7	14	11	26
Meat, poultry, eggs, fish	6	20	6	46

Sources: Data from Food and Agriculture Organization and U.S. Department of Agriculture.

Less developed countries' protein needs satisfied by cereals + beans. Now shifting to milk + meat – affecting ag production. Why?

Energy efficiency transfer from plants to humans through beef is ~1%



How were increases in the food supply able to keep up in the past with increases in population?



From 1860 to 1978 land used for food production increased.

But, since 1978, land area remained steady. Cultivated land per person dropped by 25%.





How did food production keep pace? Increased crop productivity.



1930

21%

2009 ~0.7%

% of people involved in farming: Number of farms:

6,295,000

2,200,000

BOTH DECREASED

But productivity of average US farmer INCREASED...

In 1930 fed 10

In 1960, 24

In 1990, 100

In 2009, 155





Let's look at productivity in U.S. Agriculture

Genetic improvements and more efficient farming practices helped American farmers increase productivity





Increases focused on only few crops

Globally 300 crops provide food... 24 supply most of the food and feed... 8 supply 85%!



Three account for over half of our food - directly or indirectly.







Wheat



Corn

Rice





How are these issues affecting agricultural production?

What will we do about it?



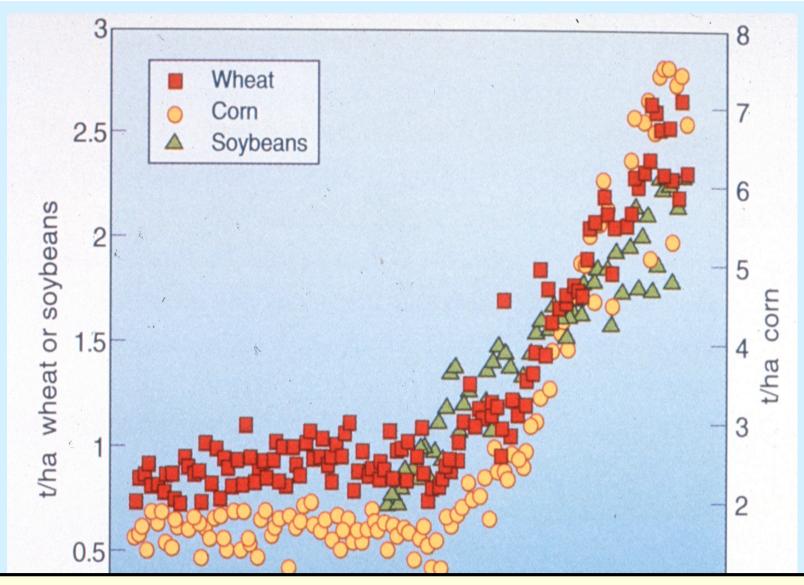












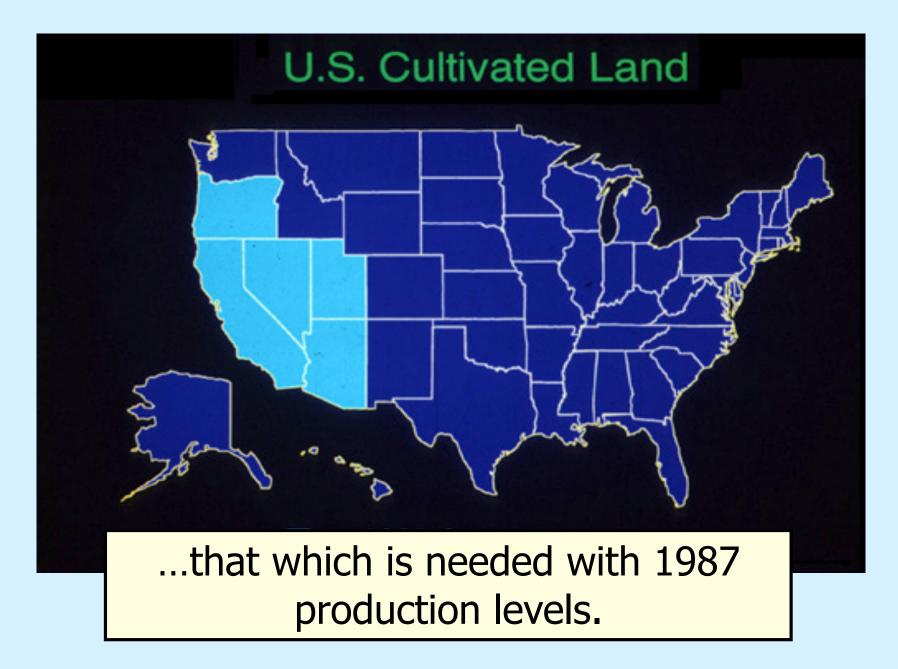
Since the 1930's breeding, inputs and farm mechanization led to dramatic yield improvements

1860 1880 1900 1920 1940 1960 1980 2000 Year











In the past how did we use genetics to create higher yielding varieties?



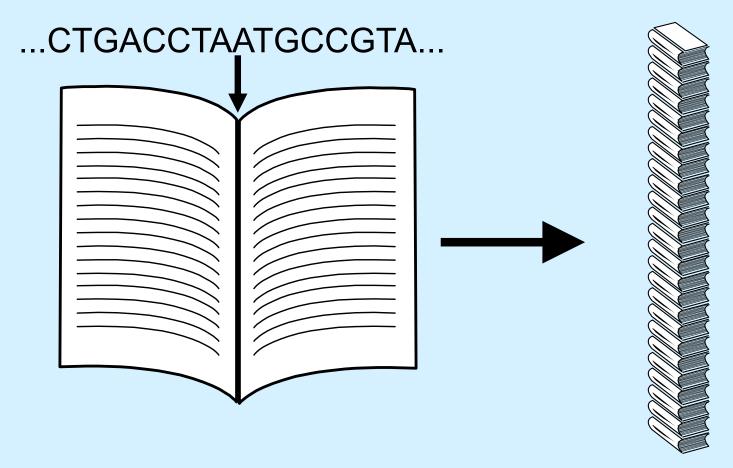
Triticum aestivum Triticum monococcum

Modern bread variety Ancient variety



Information in the wheat genome

Chemical units represented by alphabetic letters

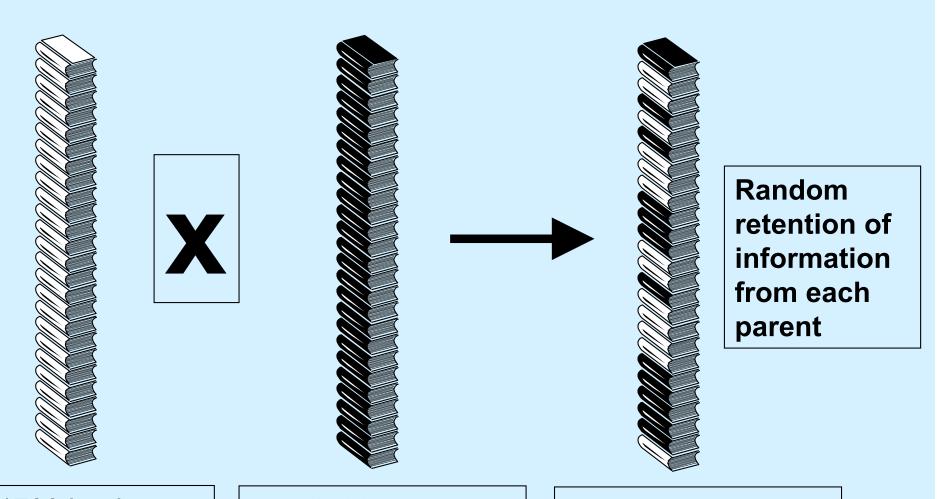


1700 books 1000 pages each

1700 books (or 1.7 million pages)



Hybridization or cross breeding of wheat



1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)

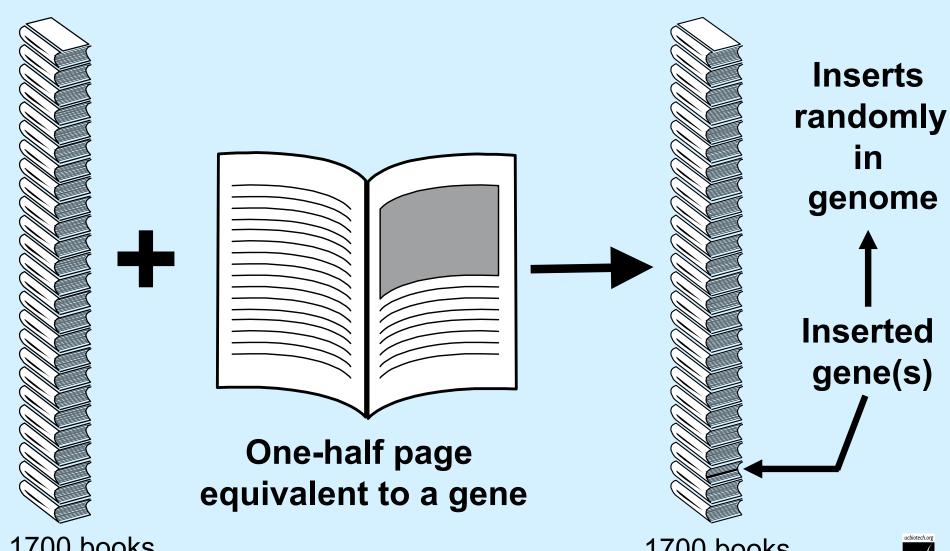


What about new genetic approaches being used to create crops?





Genetic Engineering Methods



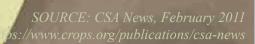
1700 books (or 1.7 million pages)

1700 books (or 1.7 million pages)





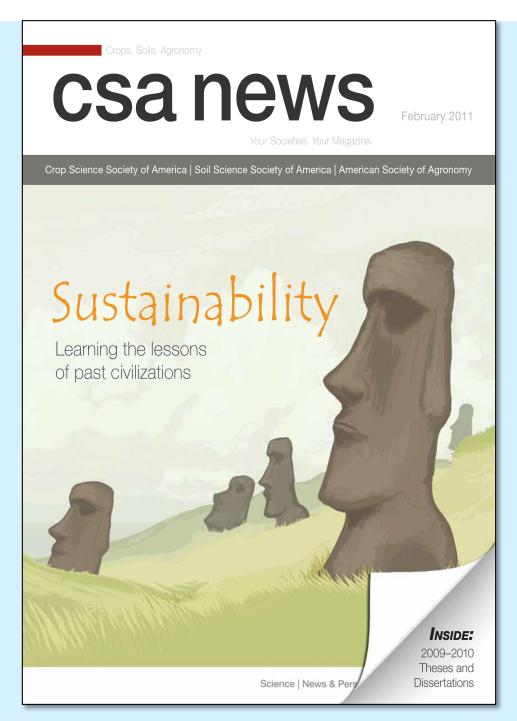
Polynesians arrived ~1,000 years ago on Easter Island, a lush, forested landscape. But 700 years later, it is estimated the last tree was axed. Chaos ensued and the society collapsed. "Fates of failed societies carry a modern day warning. We pursue unsustainable environmental practices and ignore environmental problems at our peril." Jared Diamond 2010



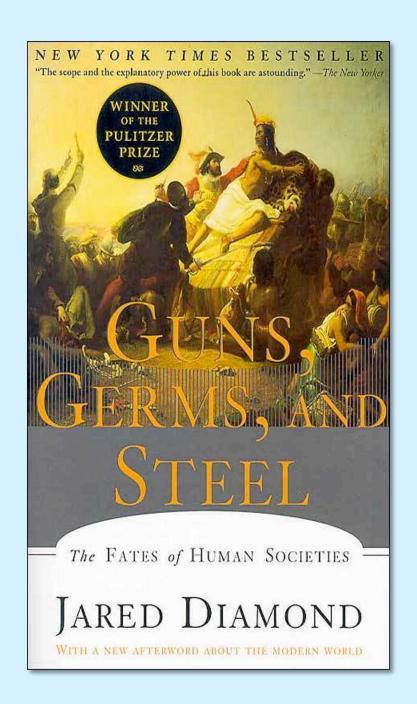
The level of agricultural productivity achieved by these improvements was needed and must actually be increased.

But are these types of agricultural productivity sustainable?

What are the challenges we face and how can we address them?







Jared Diamond on sustainability... "Forget quaint notions of sustainability...centered on cheerful things like local foods and compact fluorescent bulbs. If we don't solve our most pressing environmental challenges, including soil erosion, climate change, peak oil, and increasing consumption of global resources from a growing population, history suggests we won't survive."



Let's take a closer look at issues raised by Diamond

- Soil erosion
- Decreased water availability at some times
 - Flooding at other times
 - Rising salinity
 - Increasing temperatures
 - Changing pathogen and insect threats



Salinity



Drought

Soil Erosion



The problems are complex and require the best of a diverse number of approaches.

It is important to realize there is no one magic bullet for these challenges!



But, can GE crops help?



Soil Erosion



Experts tout conservation tillage

Colusa Farm Show workshops focus on management practices, more

By TIM HEARDEN
Capital Press



Low-till and no-till agriculture leaves fertile topsoil intact, protecting it from wind or rain and thus improving water quality and reducing soil erosion.





Roundup Ready Soybean TM

Use of herbicide tolerant soybeans has resulted in a 25-58% decrease in number of tillage operations (Carpenter 2010)



Engineered with bacterial gene to tolerate herbicide application

Water



Research

toresees

Water systems under severe strain

- > Fresh water per person: decreased four-fold in past 60 years
- ➤ Of available usable water: ~70% already used for agriculture

So, increased food production must largely he sea take place on the same land area but use less water.

e gone

depletions are simply not sustainable.' scientists warn

By DAVE WILKINS Capital Press

While skeptics continue to challenge the notion of human-caused global warming, scientists have begun to assess its potential impacts on the West's water supplies.

- Major groundwater aquifers being drained unsustainably
- > Water tables in Mexico, India, China, North Africa declining by ≥ one meter per year

Can GE Crops Help?



Water-limiting

Modifying expression of plant genes leads to greater water use efficiency

Engineered rice and maize have improved yields under water-limiting conditions

So plants must be prepared for not enough water ... but, at other times or, at the wrong times, too much water





Water at wrong time



Over 20% of the world's rice is grown in flood-prone areas

Rice engineered with gene from wild rice species can survive prolonged submergence

Water at harvest time can cause sprouting of grain on the head – and millions of dollars of losses in grain.

Downregulation of single wheat gene prevents preharvest sprouting

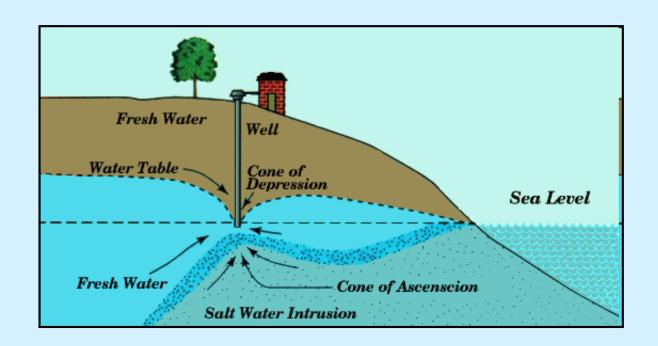


Transgenic Control



Rising temperatures

With Global climate change, temperatures will rise causing ocean temperatures to warm, sea levels to rise and marine saltwater to intrude into aquifers and wells.



Leading to salt water intrusion, but...



Plants can be engineered to be salt-tolerant

Salt-tolerant Tomatoes





Engineered

Control



Changing insect and pathogen threats

"At present, 30-40% of all crops are lost due to pest and disease before they are harvested... (this can be alleviated) with a mixture of genetic modification and conventional breeding" UK Chief Scientist John Beddington























GE grapes in the E.U. tested for protection against fan leaf virus





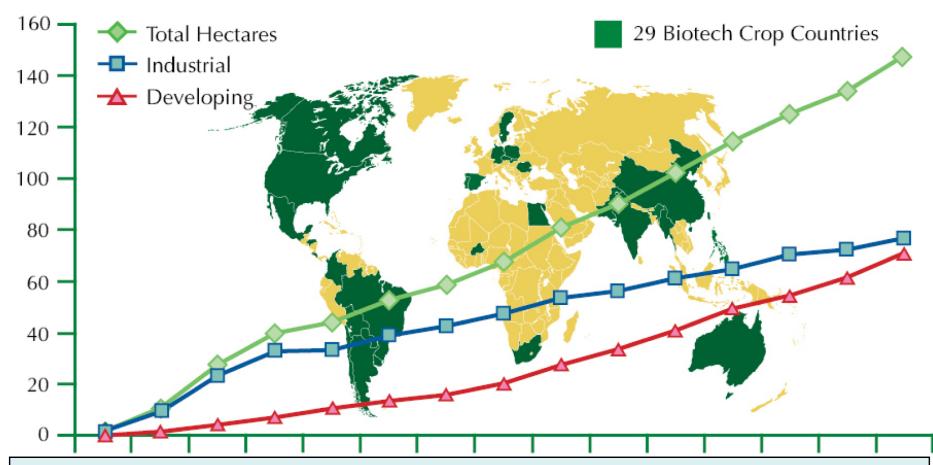








GLOBAL AREA OF BIOTECH CROPS Million Hectares (1996-2010)



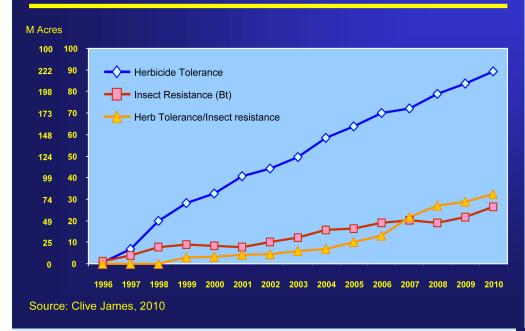
In data just released Friday, 15.4 million farmers in 29 countries planted 365M acres – and over 90% or 14.4 million were small resource-poor farmers in developing countries

Source: Clive James, 2010.



Global Area of Biotech Crops, 1996 to 2010: By Trait (Million Hectares, Million Acres)



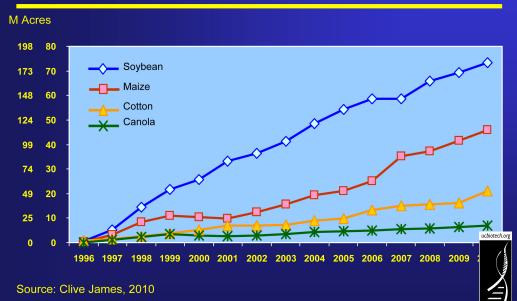


But advances for these farmers are only in a limited number of crops – not necessarily those of most value to developing countries and...

They have a limited number of traits. Does this really serve the needs of developing countries?









More of world's crops are genetically engineered

By Elizabeth Weise, USA TODAY

February 23, 2011

The amount of land devoted to genetically engineered crops grew 10% last year, and 7% in the year before, as farmers in major grain and soy exporting countries such

Lemaux says "because of the expenses involved, creating engineered crops for developing countries requires humanitarian contributions by philanthropists like (Bill) Gates and the Rockefeller Foundation, or perhaps by companies who see value in such endeavors."

And, although many academic scientists would like to play a meaningful role, they have limited resources to do so.

The situation with agricultural production in less developed countries requires a different perspective. Why? Let's look at the situation in Africa.

















Only region where both poverty and hunger continue to increase. In the past 15 years number of Africans living on < \$1 per day increased to 50%.

Banjul Barnako Niamev Chad CHAD

Nearly one-third of all men, women and children in sub-Saharan Africa are currently undernourished vs. 17% in developed world.

African farms yielded 19% less ag production per capita in 2005 than they did in 1970!!









Senegal United States

Technologies used for agriculture in Africa and other developing countries are different from those in the developed world...



Also crop productivity is lower in Africa and India vs. developed countries because yields are lower.

	YIELD (kilograms per hectare)				
CROP	Kenya	Ethiopia	India	Developed	
				World	
Maize	1,640	2,006	1,907	8,340	5X
Sorghum	1,230	1,455	797	3,910	5X
Rice	3,930	1,872	3,284	6,810	~3X
Wheat	2,310	1,469	2,601	3.110	2X
Chickpea	314	1,026	814	7,980	25X

And most Africans do not have access to the diversity of foods available in the developed world to satisfy their dietary needs.



This leads to a difficult situation in Africa today?

- One billion of the world's poorest people depend on their own agriculture for food
- ❖ 820 million people go to bed hungry each day
- Malnutrition leads to stunted physical and mental development, increased disease susceptibility

Can biological improvements in crops help?

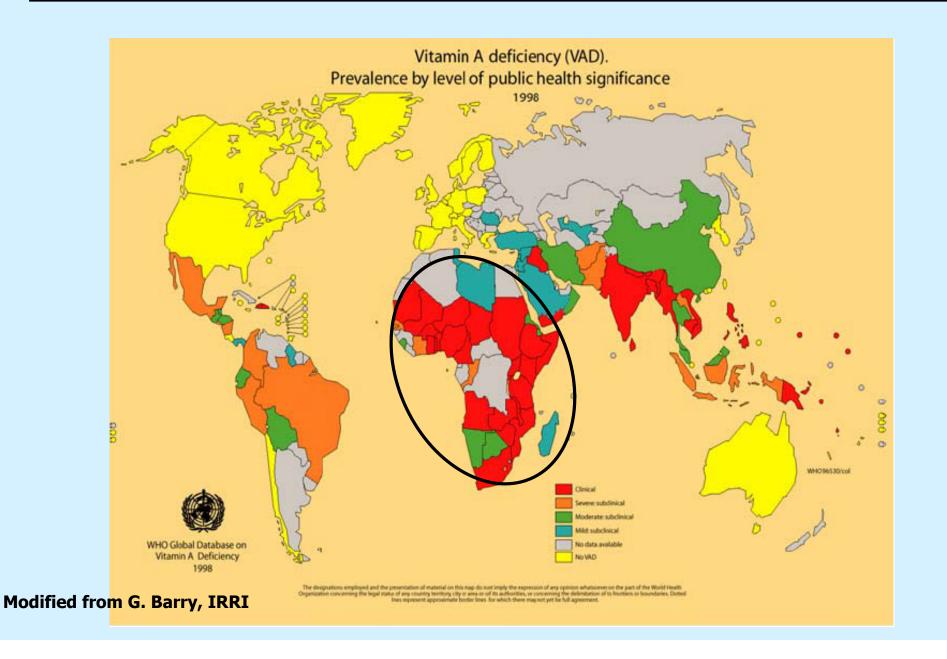


Global Development Program, Gates Foundation: http://www.gatesfoundation.org;

Starved for Science. 2008. Robert Parlberg, Harvard University Press.

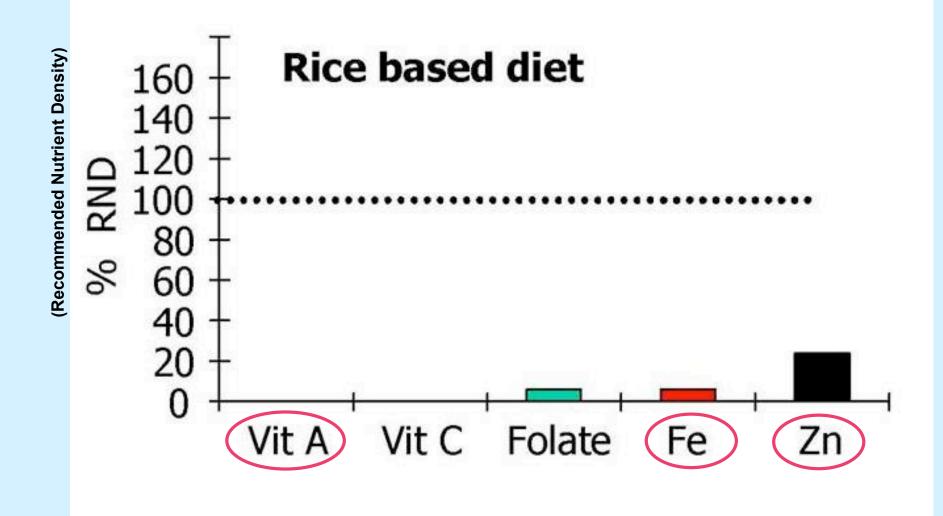


Vitamin A deficiency causes severe health problems, vision loss, poor brain development, immune system failure





In many less developed countries rice often serves as the main, or only, source of calories. Rice, like other cereal crops, is a poor source of vitamins and minerals

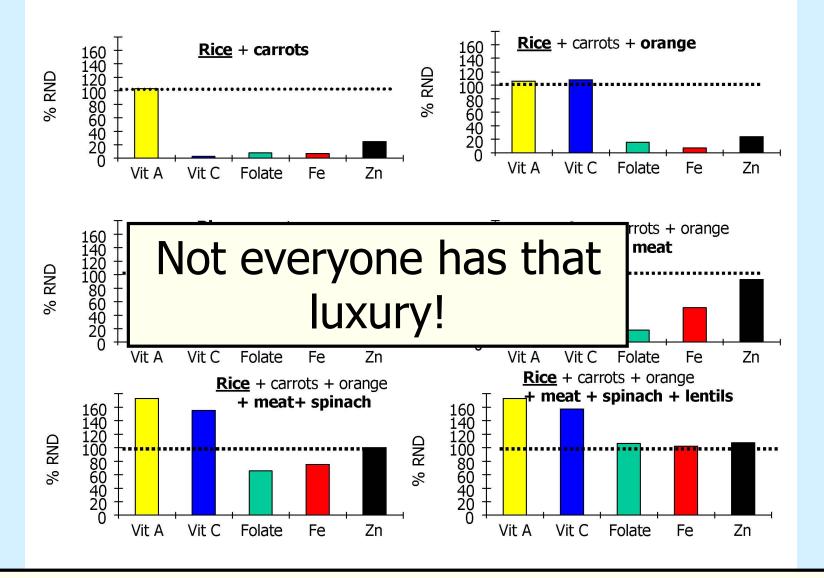




From: "Nutrition: A Cornerstone for Human Health and Productivity", Richard J. Deckelbaum.

Modified from G. Barry, IRRI

Seminar, Earth Institute of Columbia University, April 14, 2005

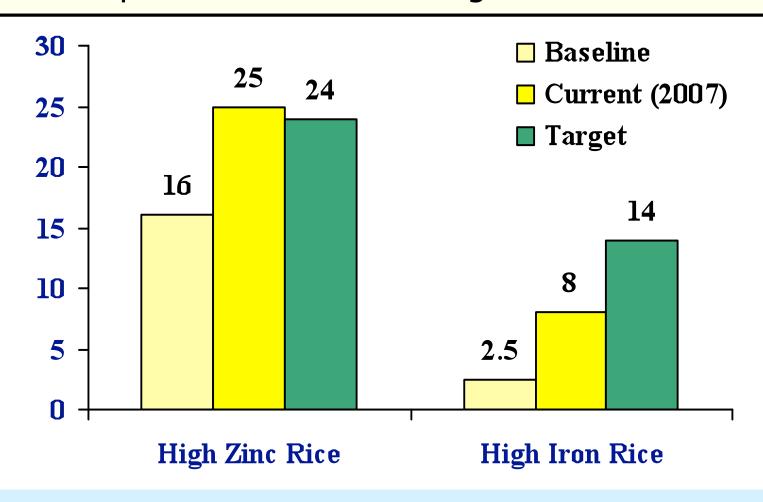


Can't rice diets just be supplemented with other fruits, vegetables and meat to add these nutrients?



Progress has been made fortifying rice with iron and zinc using cross-breeding with other varieties...

But this approach is not feasible for Vitamin A since there are no compatible varieties with high levels of this vitamin.



E. Boncodin, Fedl Budget Secy Manila Philippines

Golden Rice was engineered to have pro-Vitamin A



Normal portion of Golden Rice 2 provides half of a child's Vitamin A needs

NO MAGIC BULLET



Second cereal that is also nutritionally deficient in:
 Vitamins
 Minerals
 Amino acids
 (like most cereals)

but, uniquely, is also

Poorly Digested

What is this crop?





SeedQuest® News section

home | news | solutions | forum | careers | calendar | yellow pages | advertise | contacts

University of California, Berkeley joins Africa Biofortified Sorghum (ABS) project

naulualan dalifanaia

University of California, Berkeley Scientists join Africa Biofortified Sorghum Project

minori peopre in zanca ano reiz on sorgnam as a principar socice or rooci

The Africa Biofortified Sorghum (ABS) project is funded by a \$17.6 million grant from the Grand Challenges in Global Health initiative to Africa Harvest Biotechnology Foundation International, a non-profit organization dedicated to fighting hunger and poverty in Africa.

"Our goal is to develop sorghum that will provide increased calories and needed protein in the diet of African consumers," said Bob B. Buchanan, UC Berkeley professor of plant and microbial biology and one of the lead scientists on the project. "We are extremely happy to offer our expertise and materials for this important project for the public good."

The announcement of UC Berkeley's participation was made from Nairobi, Kenya, today (Monday, April 10) by project leader Florence Wambugu. "All the project consortium members are delighted that researchers from UC Berkeley will be joining the team," said Wambugu, who is a plant pathologist and CEO of Africa Harvest. "Their contribution will provide a second avenue to ensure success in achieving the important goal of increasing digestibility of sorghum."

The Grand Challenges in Global Health initiative is supporting nutritional improvement of four staple crops - sorghum, cassava, bananas and rice - as one of its 14 "grand challenges" projects that focus on using science and technology to dramatically

Peggy G. Lemaux, UC Berkeley Cooperative Extension specialist in plant and microbial biology, and Bob Buchanan, professor of plant and microbial biology, inspect sorghum plants in a controlled temperature growth room. (Rosemary Alonso photo)

improve health in the world's poorest countries. The initiative is funded by the Bill & Melinda Gates Foundation, the Wellcome Trust, and the Canadian Institutes of Health Research.

In June 2005, the initiative awarded \$16.94 million to Africa Harvest to head a consortium of public and private research institutes for the ABS project. The Gates Foundation has just supplemented this amount with \$627,932 to find the work of Burchasse and correspondence of Longois U.S. Borkelou Conservative Extension and initiative

Sorghum was one target for nutritional improvement for Bill and Melinda Gates Foundation Grand Challenges for Global Health – a project in which my lab and Bob Buchanan's participated.



Why Pick Sorghum?

Fifth most important food grain worldwide

 90% grown in Africa and Asia in arid and semi-arid regions

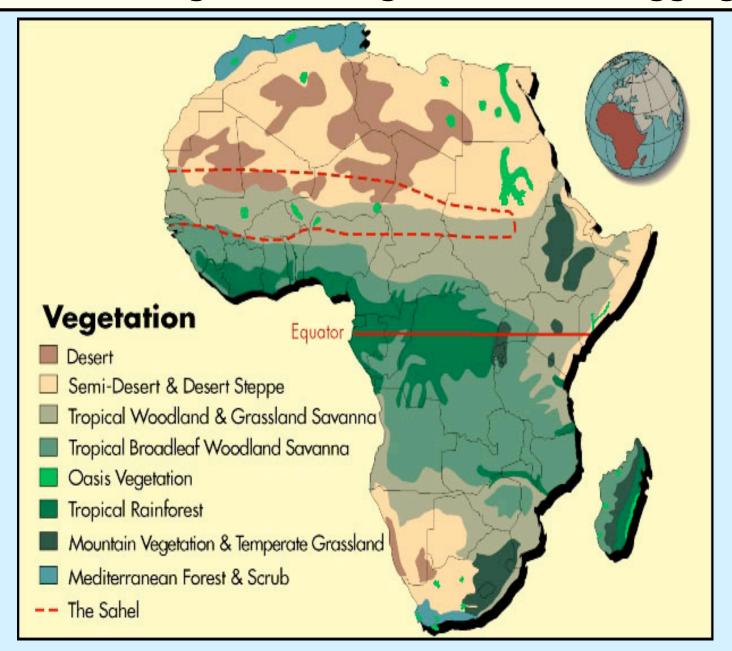
 Staple food for 300 million in Africa and, like rice, is nutritionally deficient Cultivated sorghum

Wild outcrossing species





Sorghum is uniquely adapted to Africa's climate – withstanding both drought and water logging





First successful nutritional improvement in sorghum was engineering to make provitamin A, converted to vitamin A in the body.





The ABS Project has produced the world's first golden sorghum enabling pro-vitamin A to be used as the visible marker for final ABS product

ABS Project Produces World's First Golden Sorghum

the Africa Biofortified Sorghum (ABS) Project, Dr. Florence Wambugu, told a recent Bio 2Biz SA Forum in South African that the Project had produced the world's first golden sorghum "enabling pro-vitamin A to be used as the visible marker for final ABS product".

Making her presentation "ABS Project: Networking African & International Biotech Capacities to Deliver a Nutrient Rich Product to the Needy", Dr. Wambugu said the new development was made by Ploneer scientists. She said the project has been able to significantly increase transformation efficiency, paying the way for it to transit into the Product Development & Deployment phase.

frica Harvest CEO and Coordinator of Dr. Wambugu told scientists drawn from South African research Institutions and the private sector that the ABS Project had trained 11 African scientists and breeders in a short period of less than five years. She said the project had conducted six field trials in four years and contained greenhouse work was continuing in Kenya and South Africa.

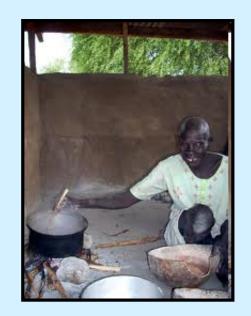
> Bio2Biz SA is hosted by South Africa's Biotechnology Innovation Centres (BICs) comprising of Bio PAD, Cape Biotech, LIFElab and PlantBio, together with the Innovation Fund and eGoli Bio. It brings together biotechnology researchers and industry to create mutually beneficial relationships. This year, the meeting was held at the Durban International Conference Centre (ICC) from September 20th to 23rd.



But digestibility remains a problem because...

In Africa, 74% of sorghum is consumed at home as cooked porridge

Elderly woman making cooked sorghum porridge

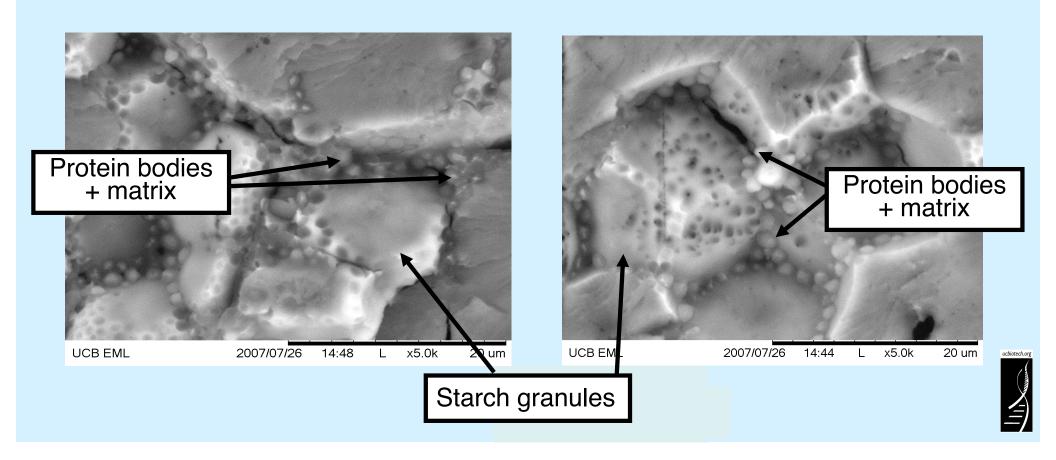


But, of major cereals, sorghum is the least digestible following cooking

% Digestibility					
Cereal	Uncooked	Cooked	Decrease		
Sorghum	80.8	56.3	24.5 ←		
Maize	83.4	79.3	4.1 ←		
Barley	93.2	80.2	13.0		
Rice	91.1	82.1	9.1		
Wheat	91.3	85.9	5.4		



Our efforts continue on improving digestibility by interfering with the chemical connections between proteins that interfere with starch and protein digestibility upon cooking.



Is Farming Conventionally a Magic Bullet?



Are Genetically Engineered Crops a Magic Bullet?





Is Farming Using Organic Practices a Magic Bullet?

Future farming will be complex, requiring all skills and technologies available. The wise use of the best of each approaches offers the best way to achieve sustainable food production to feed future populations.





SCIENCE-BASED INFORMATION & RESOURCES ON AGRICULTURAL BIOTECHNOLOGY

HOME IN THE NEWS | BIOTECHNOLOGY INFORMATION | SCIENTIFIC DATABASE | RESOURCES | LINKS | GLOSSARY | CONTACT

know gmos

This website, developed for the University of California Division of Agricultural and Natural Resources Statewide Biotechnology Workgroup, provides educational resources focused broadly on issues related to agriculture, crops, animals, foods and the technologies used to improve them. Science-based information related to these issues is available, as well as educational tools and information, which can be used to promote informed participation in discussions about these topics.



BIOTECHNOLOGY INFORMATION



Review articles: Focused on food, environmental and socioeconomic issues of GE crops and foods.

RESOURCES FOR OUTREACH & EXTENSION, RESEARCHERS & TEACHERS



Sitde Archive

Extensive collection of PP slides on agriculture & biotechnology.

Available on loan

Educational displays: "Genetics and Foods" and Genetic Diversity and

HELPFUL SITES



Seed Biotechnology Center Mobilizes research, education & outreach efforts in partnership with seed &

biotechnology industries

For more information: ucbiotech.org and Lemaux PG. *Annual Review of Plant Biology* 2008 & 2009

TIG Tag Grow; cougational game to teach what 1000s come from what crops.

