Global Food Security Germplasm Connections: New Crop Varieties in Food-Insecure Countries

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Growing, Innovating, and Celebrating 150 Years
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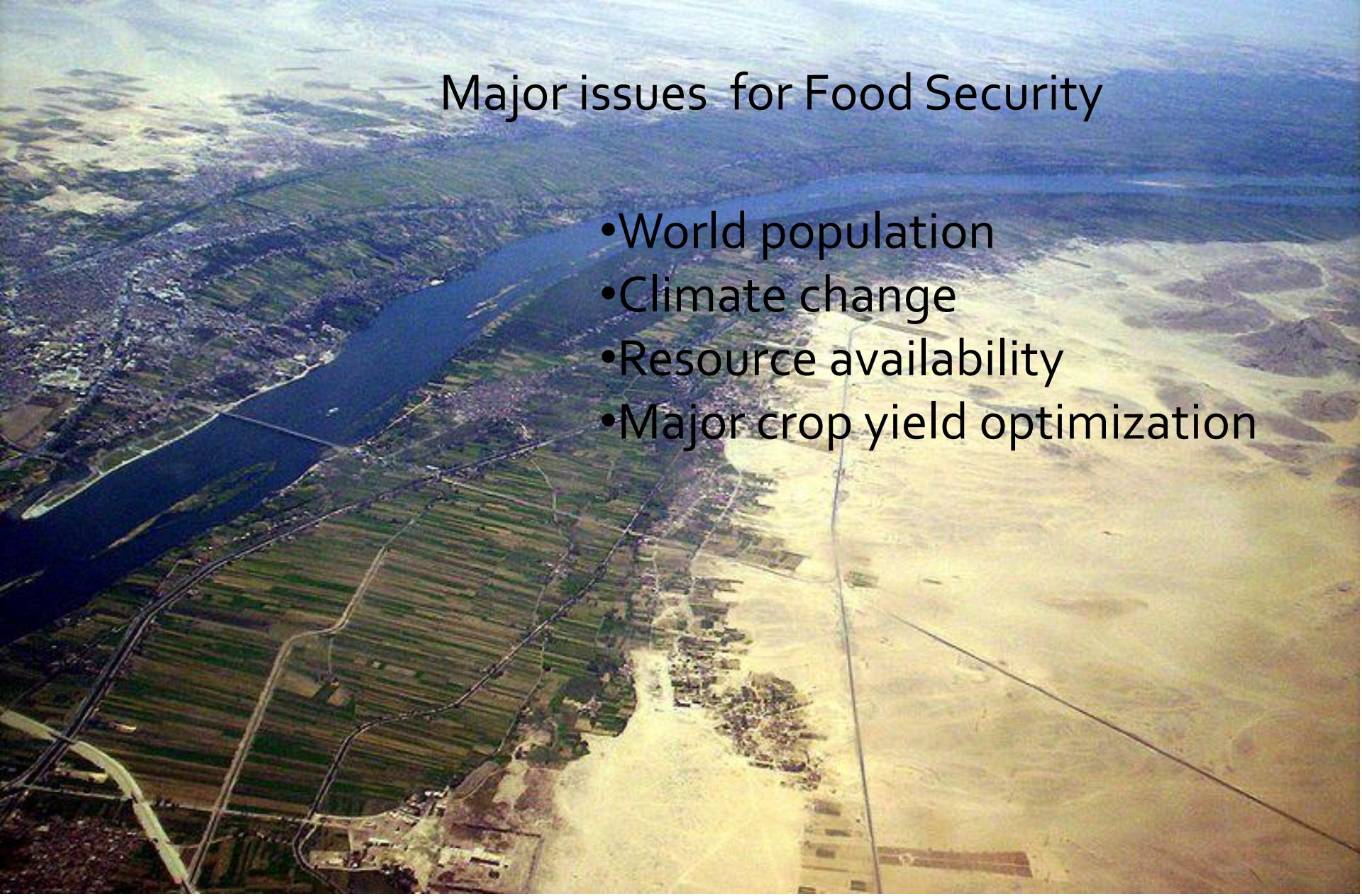
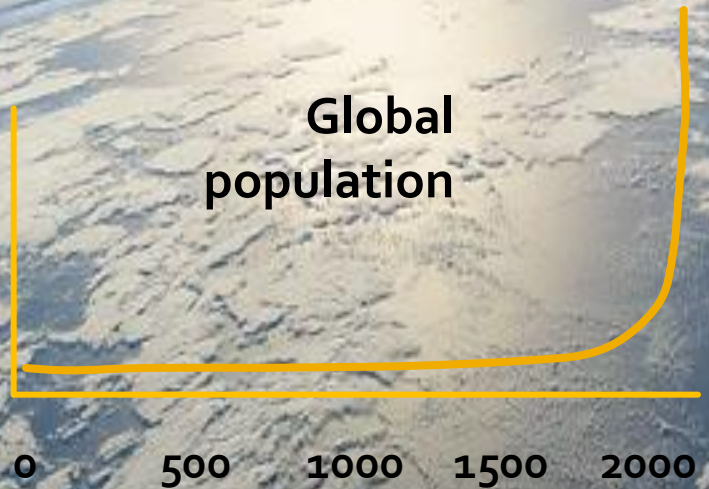
Major issues for Food Security

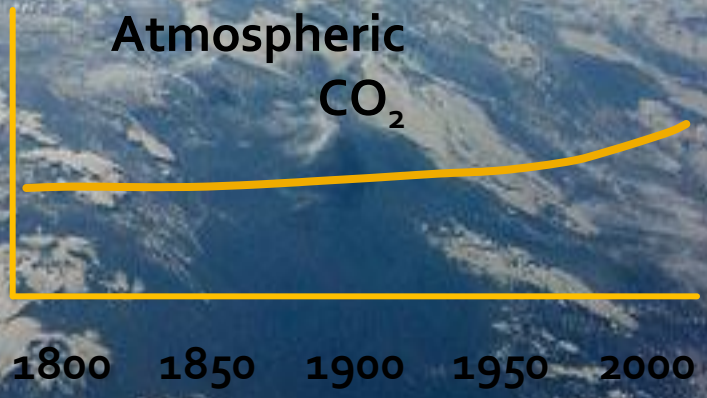
- World population
- Climate change
- Resource availability
- Major crop yield optimization



Irrigation Canal have opened up the desert areas for agriculture along the Nile River, Egypt

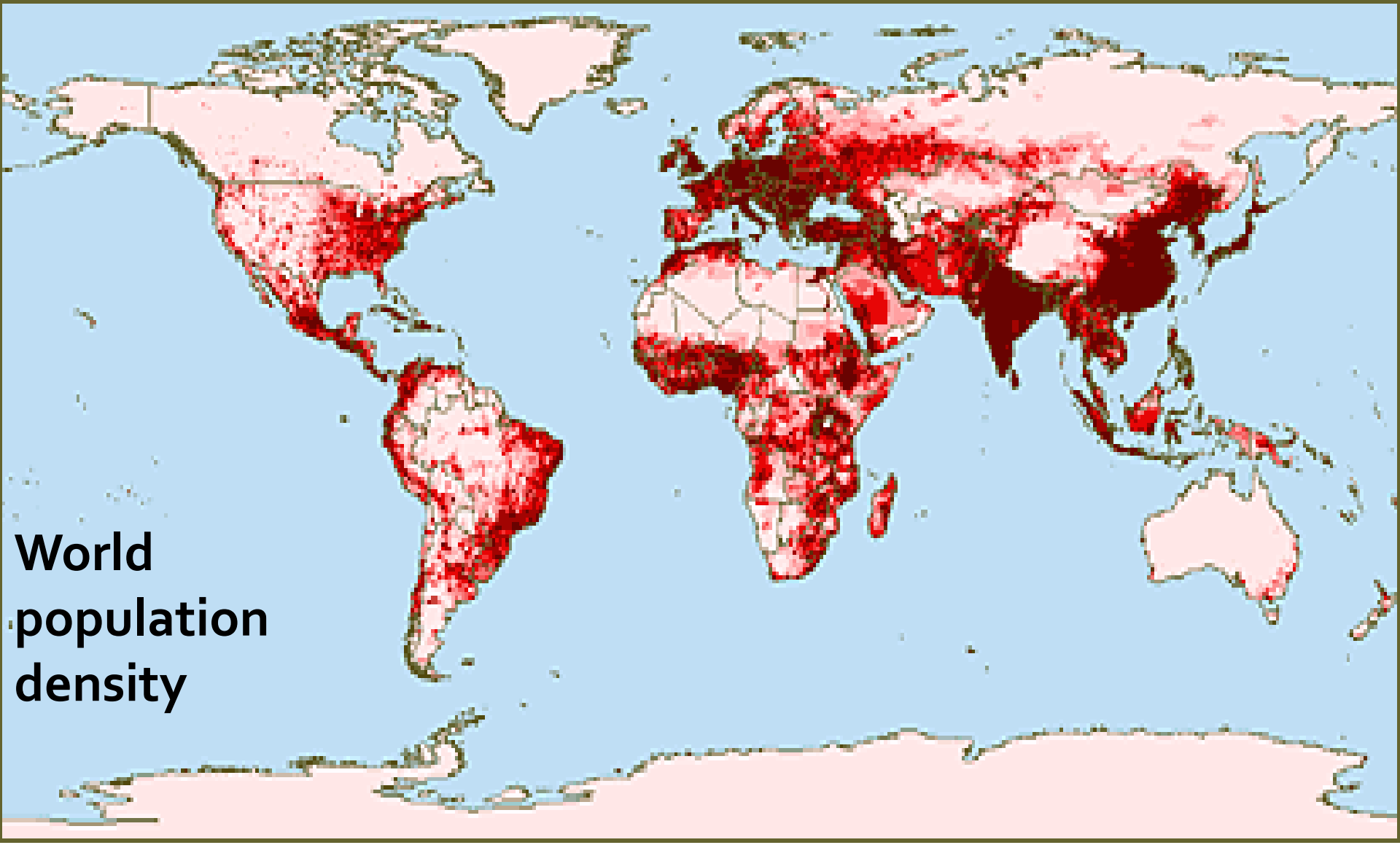
Facing our biggest challenges





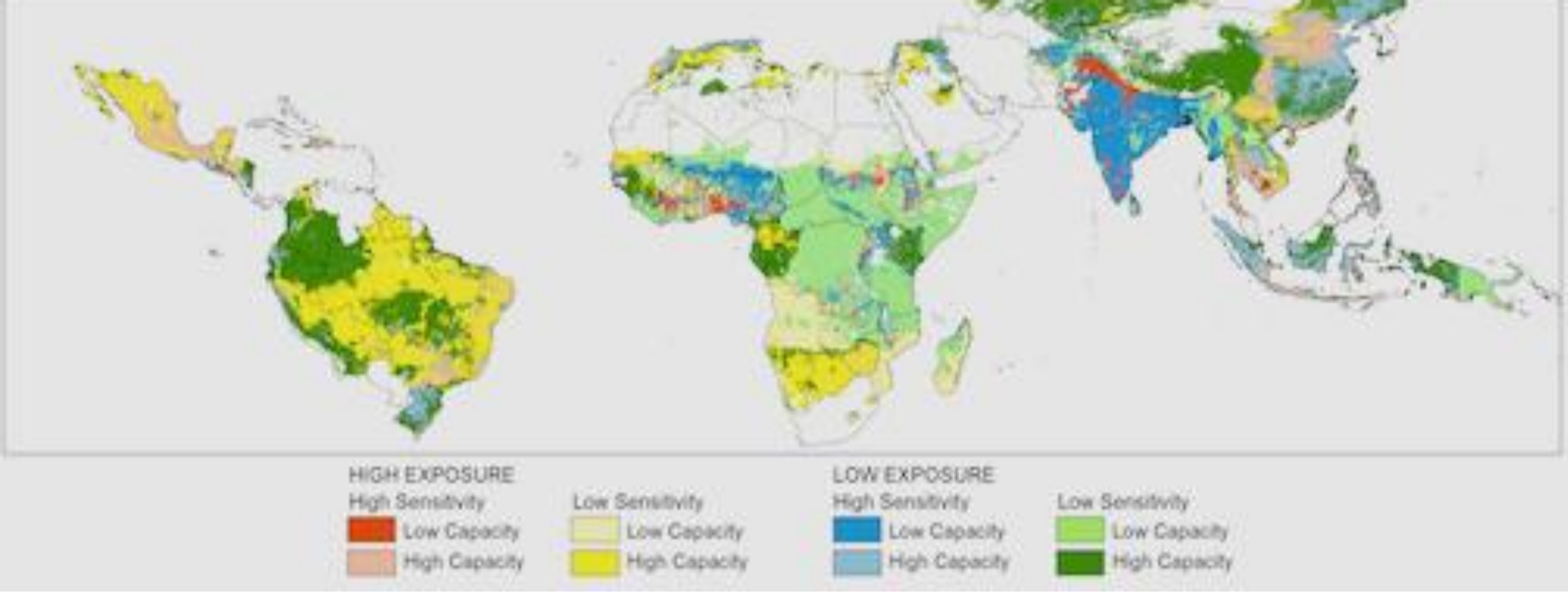
How do we feed more people without further damaging our planet?

Photo courtesy Earth Observatory NASA



World Population 7 billion (2011)
United Nations, 2010 Revision of the World Population Prospects world population reached 7 Billion on October 31, 2011

The US Census Bureau has a lower estimate, for which the 7 billion mark will only be reached on March 12, 2012



Five percent reduction in crop season, sensitivity to change, capacity to cope

CGIAR

CLIMATE CHANGE AGRICULTURE AND FOOD SECURITY

Earth System Science Partnership

ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE

Study Reveals Future "Hotspots" of Risk for Hundreds of Millions Whose Food Problems are on a Collision Course with Climate Change

Scientists Warn Disaster Looms for Parts of Africa and India if Chronic Food Insecurity Converges with Crop-wilting Weather; Latin America also Vulnerable

Press release
July 11, 2011

GLOBAL CROP DIVERSITY TRUST
A Foundation for Food Security

Crop Diversity Topics
Analysis and Reflections

Who's Counting?

The Global Crop Diversity Trust ensures the conservation and availability of crop diversity for food security worldwide.

Global food production is still increasing, but yield increases are slowing noticeably. Annual yield increases above 2% for major crops, enjoyed until recently, have now fallen substantially below that mark.

Global Yield Growth Rates (% per year)

Crop	1960-1990	1990-2007
corn	2.20	1.77
wheat	2.95	0.52
rice	2.19	0.96

Reduction in productivity growth related to declining growth in agricultural R& D spending; many major countries

Producer groups warn major investment in R& D needed

Source: Alston, Beddow, Pardey (2010)

Plant Genetic Resources contribute to the solution: What are they?

- ✓ Raw material for new crop varieties
  - Current and obsolete cultivars
  - Traditional landraces / farmers' varieties
  - Elite breeders' lines
  - Wild relatives and wild sources of food
- ✓ Global Interdependency for food security; no country can do it alone
- ✓ Requires on-going human management; *ex situ* conservation
- ✓ Farmers need new crops to face new challenges, pests, market conditions, global climate change, opportunities
- ✓ Value to agriculture lies in diversity within a crop, not at the species level

Genebanks International

- 7.4 million accession worldwide
  - 20% increase since 1996
  - much duplication; about 1/3 unique
  - increase in minor crops and crop wild relatives
- 1750 genebanks worldwide
- 8 countries hold > 45% of germplasm accessions: USA, China, India, Russia, Japan, Germany, Canada, Brazil

Major crops and world holdings

Crop	# accessions	Holders
wheat	856,168	CIMMYT, USA, China, India
rice	773,948	IRRI, India, China, Japan
barley	466,531	Canada, USA, Brazil, ICARDA
maize	327,932	CIMMYT, Portugal, USA, China
bean	261, 963	CIAT, USA, Brazil, Mexico
sorghum	235,688	ICRISAT, USA, China, India
soybean	229,944	China, USA, Korea, AVRDC
oat	130,653	Canada, USA, Russia, Germany
groundnut	128,435	ICRISAT, India, USA, Argentina
chickpea	98,313	ICRISAT, India, ICARDA, Australia

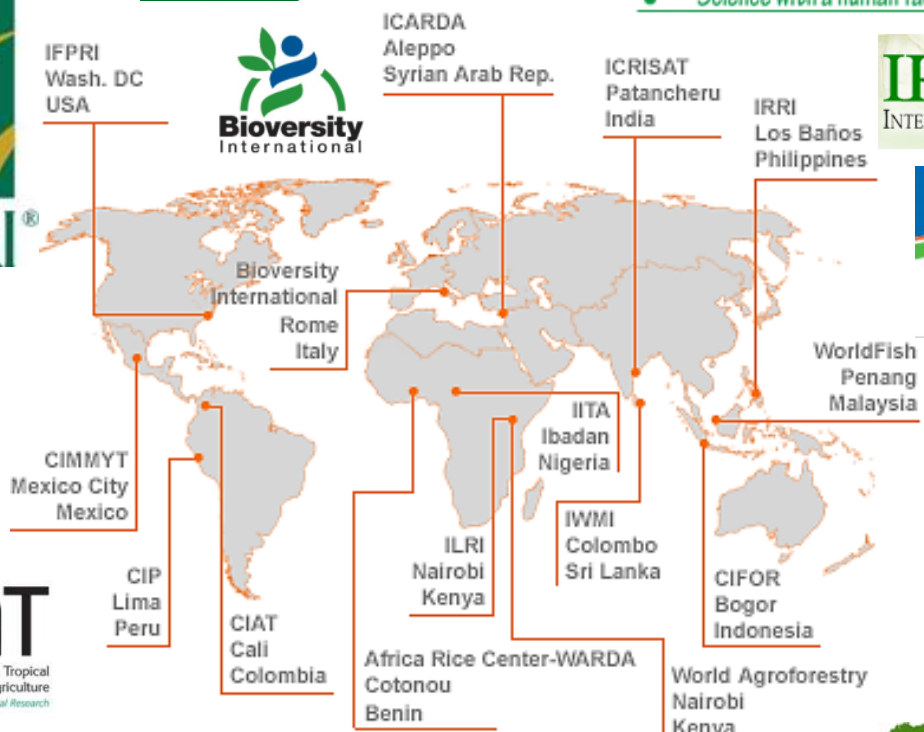
Role of genetic resources for plant breeding in addressing global challenges?

Examples from 3 of 12 important world crops: wheat, rice, cassava

Photo credits: Xochiquetzal Fonseca/CIMMYT and IRRI

Consultative Group on International Agricultural Research CGIAR

CGIAR is an international organization of agricultural research groups



International Center for Agricultural Research in the Dry Areas

ICRISAT Science with a human face

IRRI International Rice Research Institute

WorldFish Center

CIFOR

IITA Research to Nourish Africa

IWMI International Water Management Institute

CIMMYT International Maize and Wheat Improvement Center

CENTRO INTERNACIONAL DE LA PAPA CIP

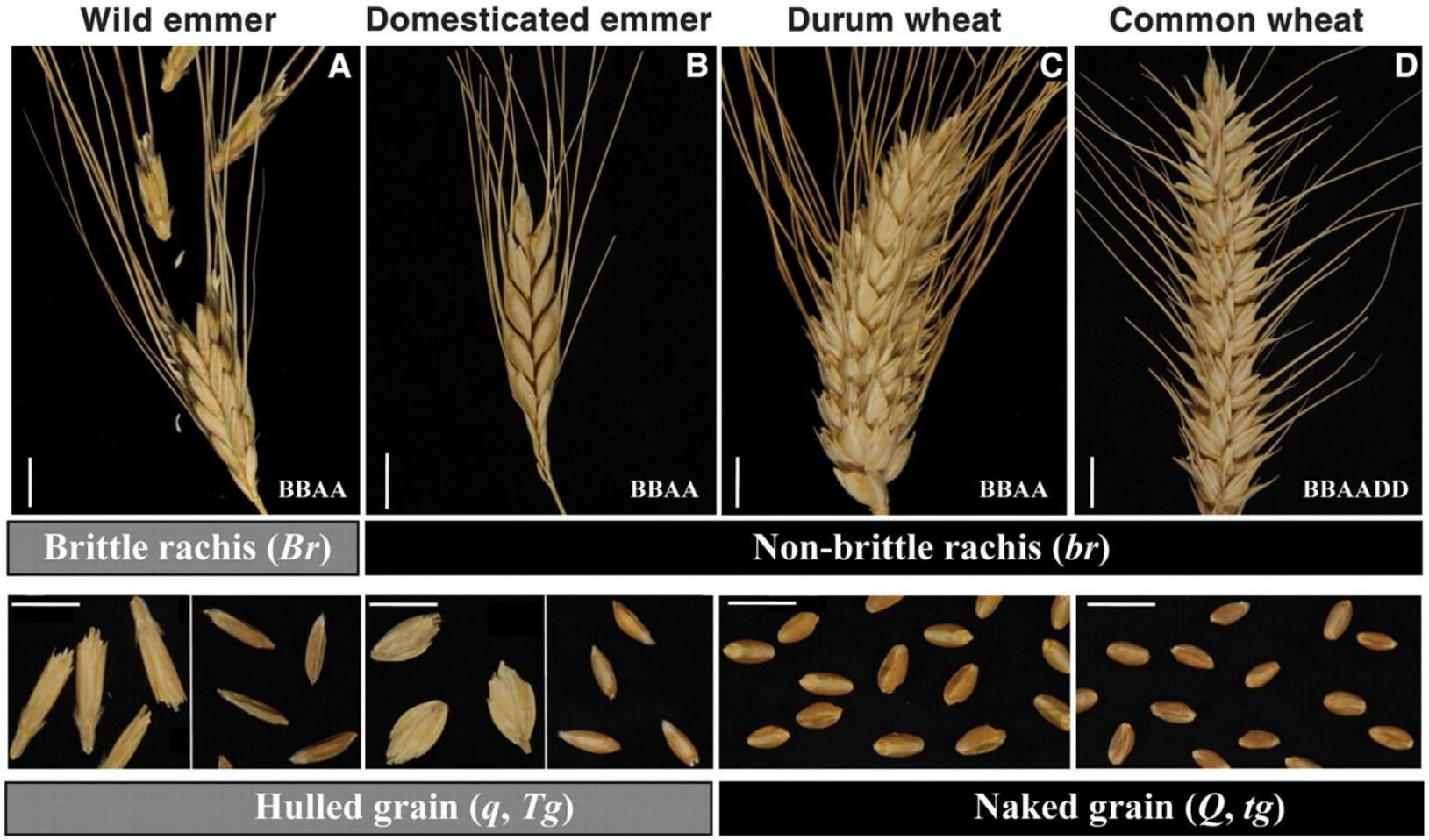
CIAT Centro Internacional de Agricultura Tropical International Center for Tropical Agriculture Consultative Group on International Agricultural Research

Africa Rice Center Centre du riz pour l'Afrique AfricaRice

ILRI International Livestock Research Institute

World Agroforestry Centre TRANSFORMING LIVES AND LANDSCAPES

Wheat domestication through genome modification = modern crops



From Dubcovsky, J. and Dvorak, J. (2007). Genome Plasticity a Key Factor in the Success of Polyploid Wheat Under Domestication. Science. **316:** 1862-1866. Reprinted with permission from AAAS.

Norman Borlaug, plant breeder, and "father of the green revolution"

Distinguished plant breeder and Nobel Laureate Norman Borlaug **1914-2009**

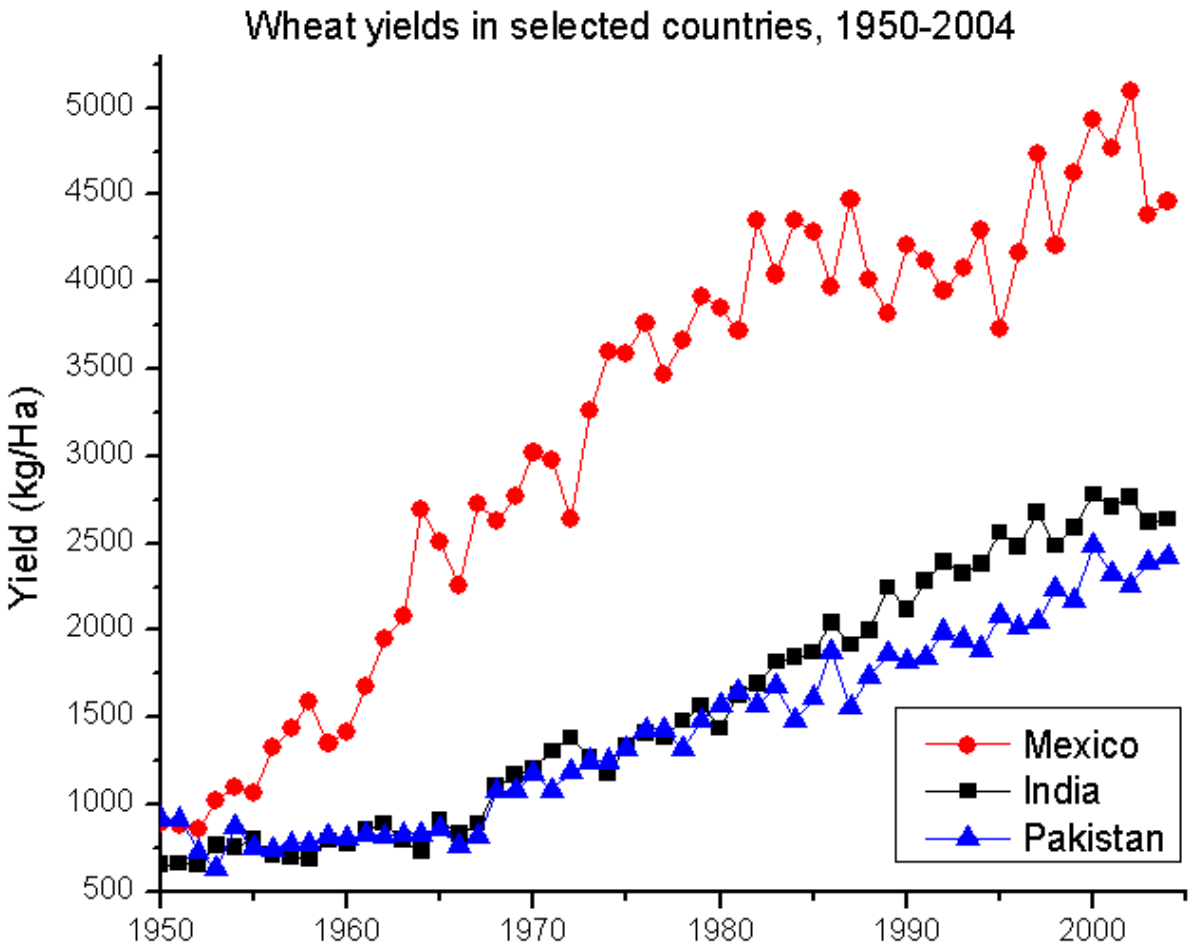
One of the most significant accomplishments of 20th century science was the development of lodging-resistant, high-yielding semi-dwarf grain varieties

CIMMYT based

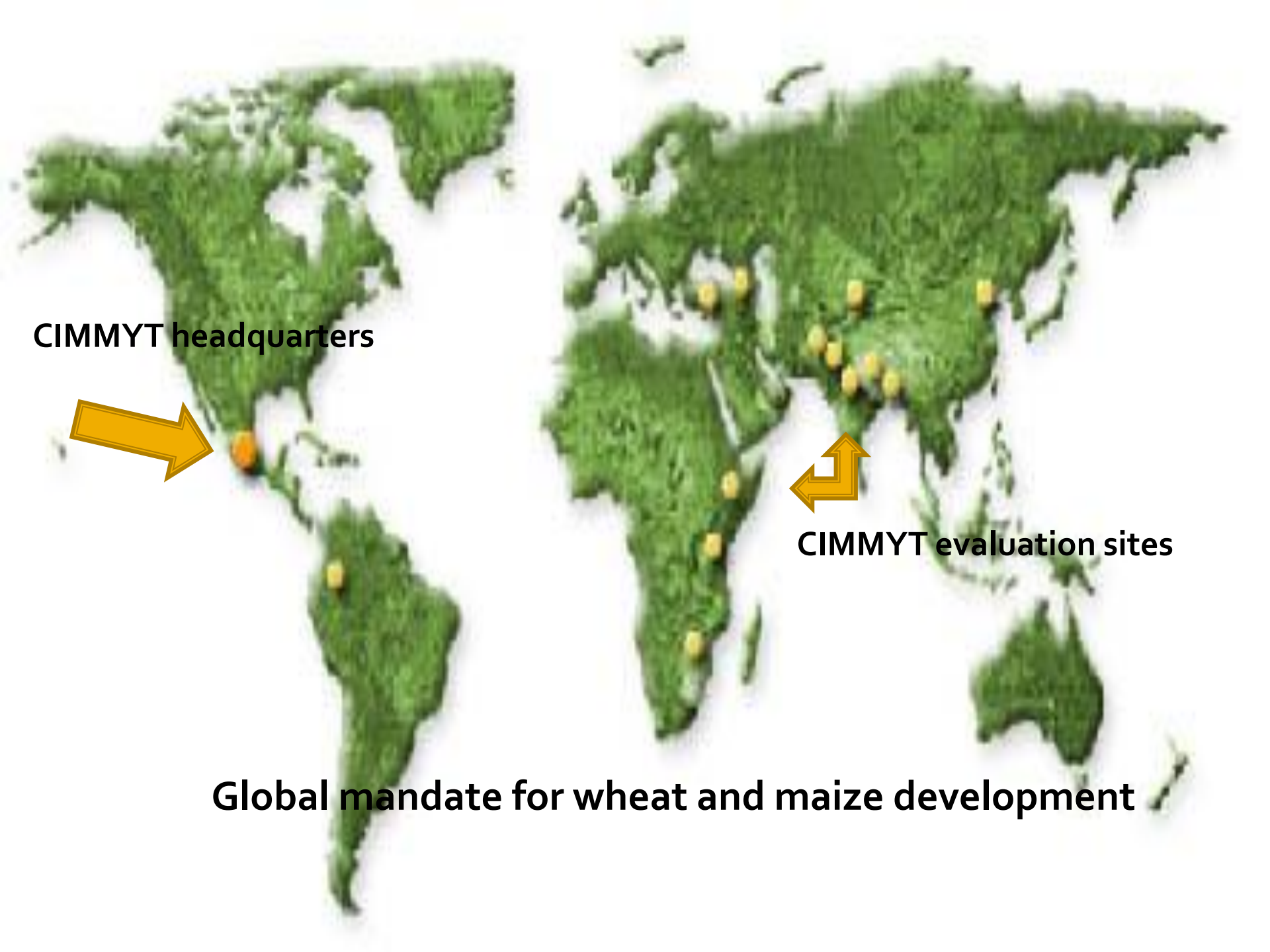
Improved green-revolution plants led to dramatically increased crop yields

The introduction of disease-resistant, semi-dwarf varieties turning countries from grain importers to grain exporters

Dwarf wheat was developed at CIMMYT – the International Maize and Wheat Improvement Center



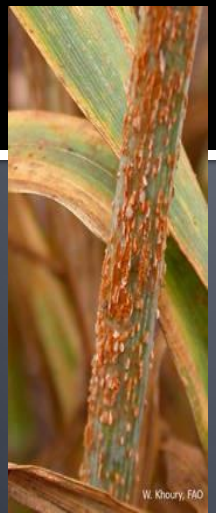
Source: FAO via Brian0918



Global mandate for wheat and maize development

Two UG99-resistant wheats developed in Kenya

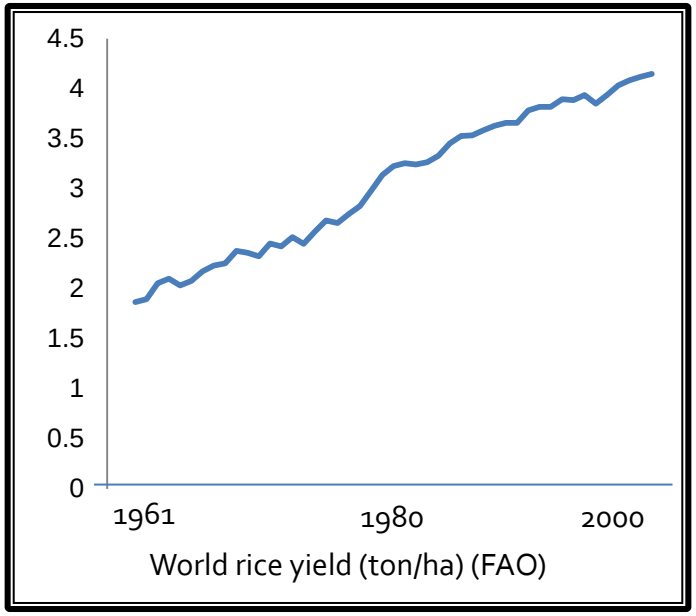
- stem rust strain spreading across Africa, to Asia and Middle East
- first discovered, Uganda, 1999
- reduces yields by 50-70%; major threat to world food security
- two Kenyan varieties (Eagle 10, Robin) have resistance
- developed by Kenya Agricultural Research Institute
  - screened 200,000 wheat accessions; diverse sources
  - 10% with some level of resistance
  - very few adapted to African environment



RICE: IIRI = International Rice Research Institute, Los Banos

Laguna, Philippines Global mandate, focus Asia

Rice breeding at IRRI brought huge yield increases



IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

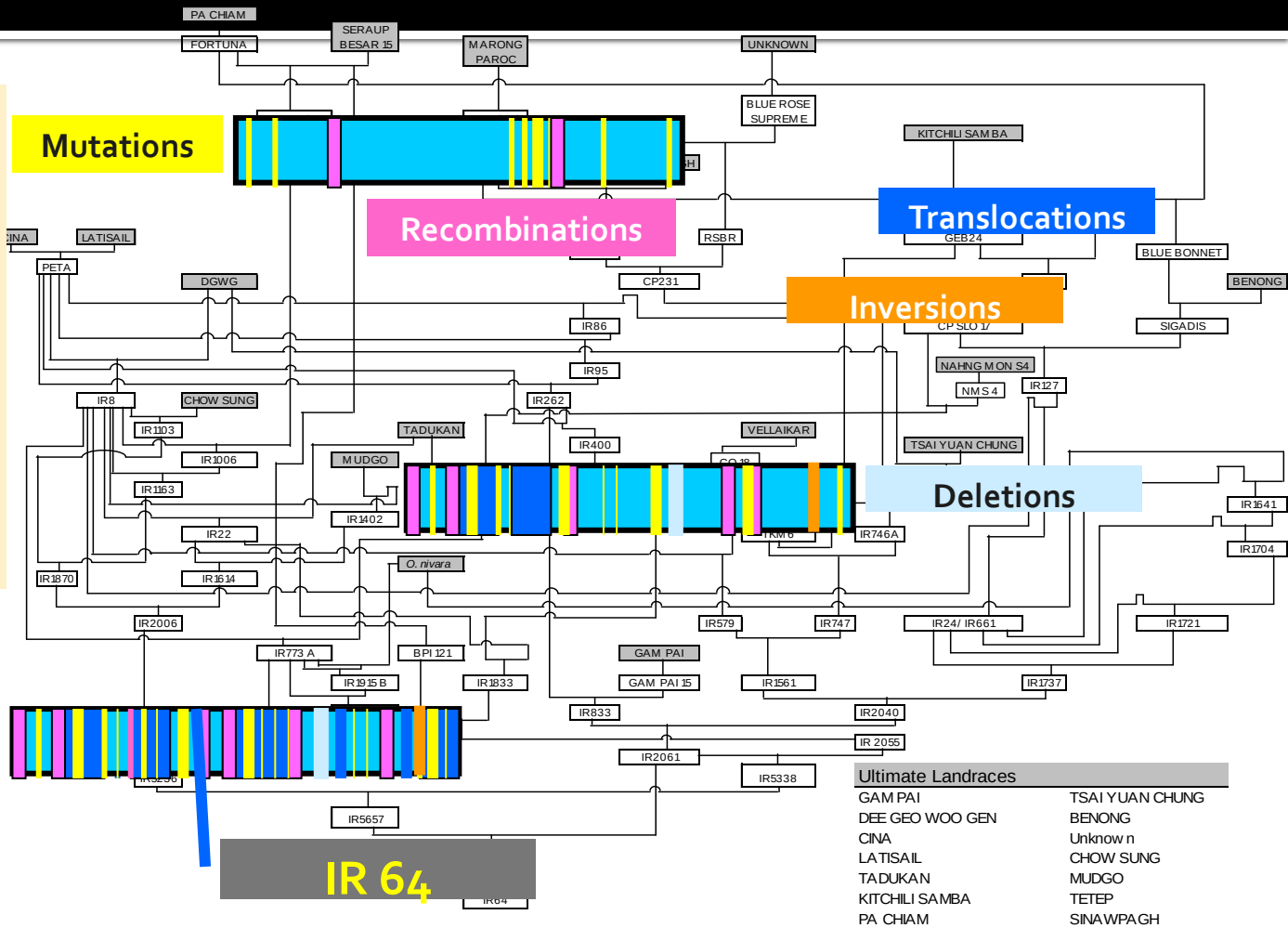
IR8, released in 1966, "*…was to tropical rices what the Model T Ford was to automobiles*." It was known as "miracle rice" because of its high yields.

Photo courtesy IRRI

Breeding tree of Indica Rice IR64

original rice genome

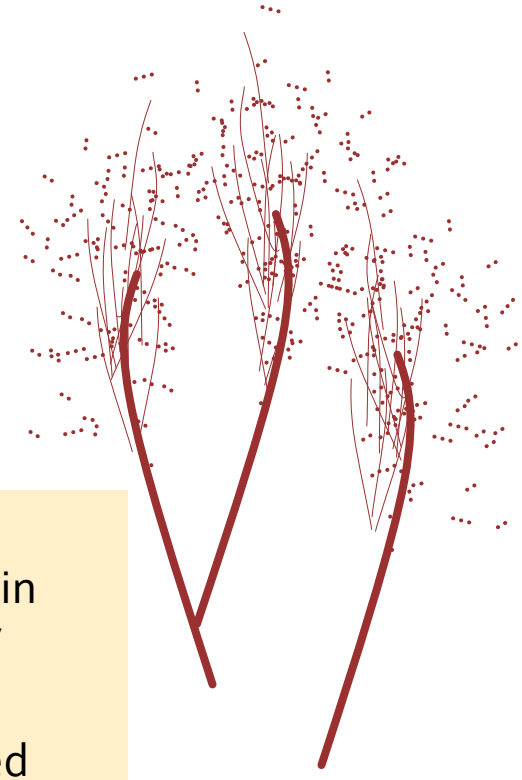
One of the most widely grown crops, Indica rice IR64 is the product of a complex breeding program resulting from extensive genomic modification, mutation, deletion and rearrangement

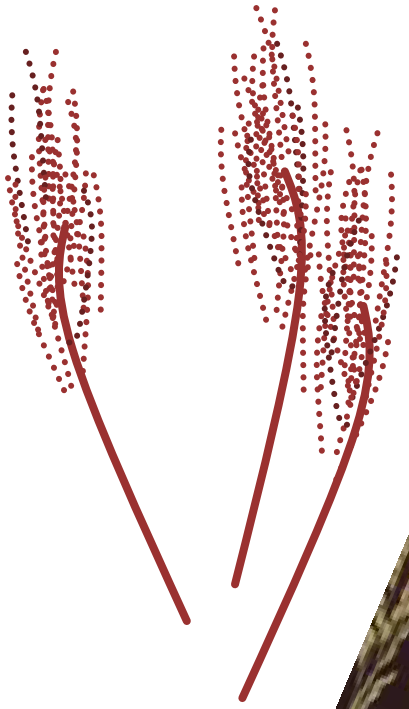


Ultimate Landraces	
GAM PAI	TSAI YUAN CHUNG
DEE GEO WOO GEN	BENONG
CINA	Unknown
LATISAIL	CHOW SUNG
TADUKAN	MUDGO
KITCHILI SAMBA	TETEP
PA CHIAM	SINAWPAGH
SERAUPBESAR 15	UNKNOWN (JAPANESE)
NAHNG MON S 4	*O. nivara* (IRGC 101508)
VELLAIKAR	MARONG PAROC

Slide courtesy of Hugo Potrykus

Early research: seeds that don't shatter were selected: increased yield, not leaving it on the ground





Wild
Shattering grain
"Brittle rachis"
Advantage – maximizes seed dispersal

Domesticated
Non-shattering grain
"Tough rachis"
Advantage – facilitates harvesting

From Konishi, S., Izawa, T., Lin, S.Y., Ebana, K., Fukuta, Y., Sasaki, T., and Yano, M. (2006). An SNP caused loss of seed shattering during rice domestication. Science 312: 1392-1396. Reprinted with permission from AAAS.

Molecular tool: Marker Assisted Selection used as a tool in production of submergence tolerant rice

Many rice-growing regions are prone to flooding.

In **Pakistan**, 2010 a huge, deadly, flood submerged 17 million acres (69,000 km²) and destroyed much of the rice harvest .

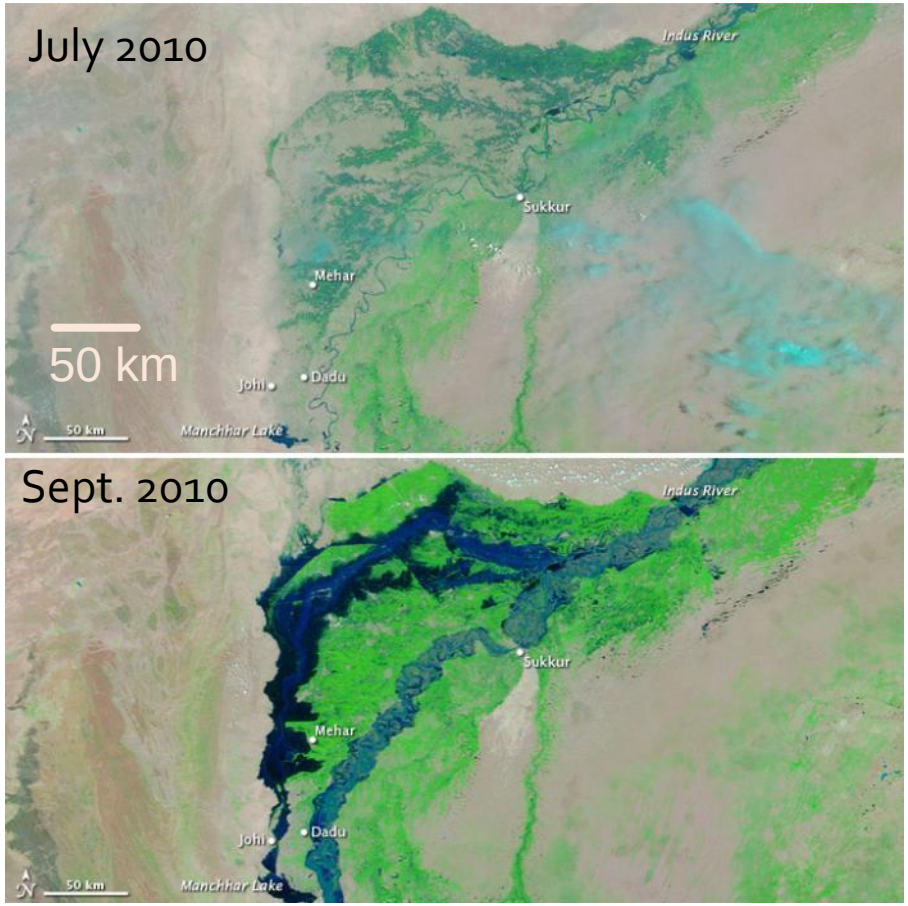
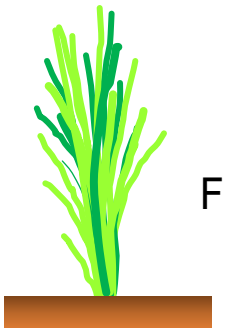


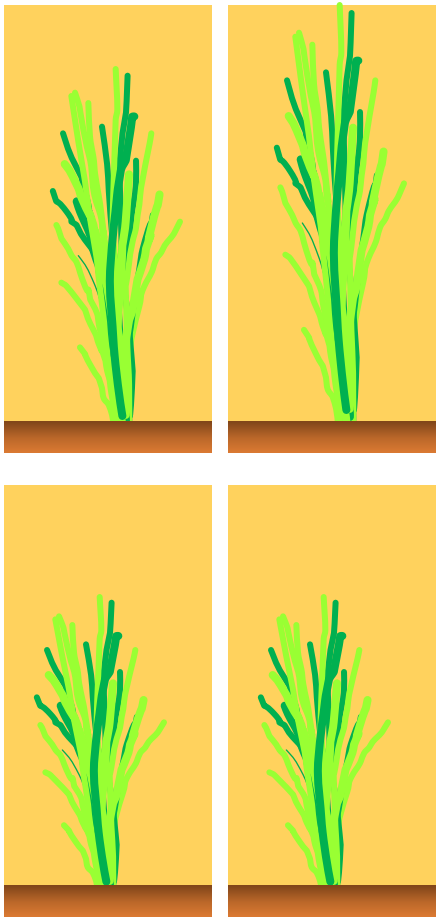
Photo credits: Abdul Majeed Goraya / IRIN; NASA Goddard

Submergence-tolerant rice can survive floods as long as 17 days

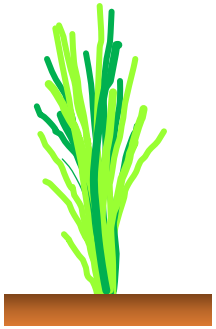
Sensitive rice – cannot survive prolonged flooding



FLOODING



Water retreats



Submergence-tolerant *Sub1* rice – growth arrests during flooding, enhancing survival

Cassava

*3rd largest source of carbohydrates in the tropics
*basic diet for about ½ B people
*new variant of a cassava disease Cassava Brown Streak Disease (CBSD) affecting large parts of East Africa; $2B damage
*None of the varieties currently distributed to farmers seem to be tolerant
*Genetic resource collections providing sources of resistant germplasm
  *5436 accessions CIAT (Columbia)
  *2889 accessions CNPMF (Brazil)
  *2756 accessions IITA (Nigeria)
  *1327 accessions ICAR (India)
*since 2007 regional plant breeding
  -4 varieties Zanzibar
  -8 varieties Nigeria by IITA & partners
  -8 varieties Tanzania
  -Uganda: breeding underway

Is Thomas Malthus and his theory of population (or catastrophe) (1798) correct 214 yrs later?

- **He foresaw a forced return to subsistence-level conditions once population growth had outpaced agricultural production.**

- Can the world feed so many people?
  - **Answer: Qualified yes**
- Next decades will be rough:
  - **Climate change**
  - **Productivity with low nutrition**
  - **Poverty continuance**
  - **Distribution challenges**
  - **Inadequate govt policies**
  - **Underfunded AGR R&D**
  - **Economic vs environmental clashes**
- **Gene banks and genetic resources will play a crucial role in food security**